SUPPLEMENT.

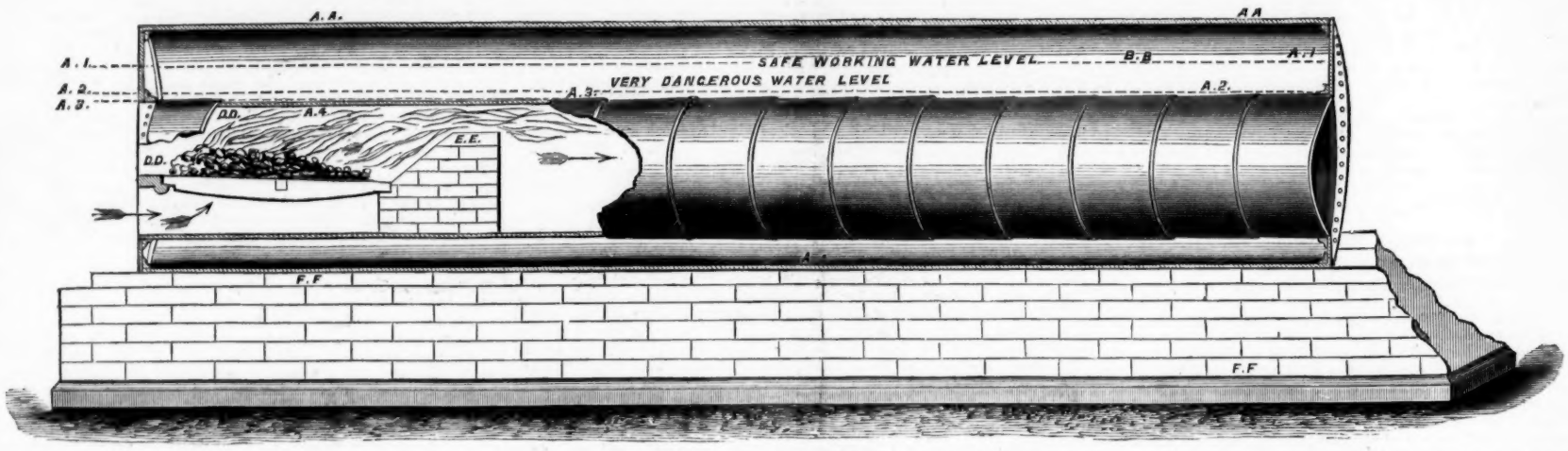
The Mining Journal,

RAILWAY AND COMMERCIAL GAZETTE:

FORMING A COMPLETE RECORD OF THE PROCEEDINGS OF ALL PUBLIC COMPANIES.

No. 1807.—Vol. XL. LONDON, SATURDAY, APRIL 9, 1870. {STAMPED .. SIXPENCE. UNSTAMPED. FIVEPENCE

COLLAPSE OF TUBES IN CORNISH BOILERS.



A A, outer shell or case of boiler. *B B*, water and steam room. *C C*, fire-tube. *D D*, furnace. *E E*, bridge. *F F*, seating or bed of boiler on bottom of flue, having a run of (say) 2 in. on the whole length.
Dotted lines—*a* 1, water at safe working height, or from 6 in. to 8 in. on the back of the tube. *a* 2, Water-line when it has sunk to a very dangerous level. *a* 3, Water-level at the point of collapse in ordinary boilers.
a 4, Fusible plug, which is protected by water until nearly the whole length of tube is dry.

COLLAPSE OF TUBES IN CORNISH BOILERS.

SIR,—This subject, theoretically considered, would at first sight lead to the inference that collapse beyond the bridge occurred or was due to the inherent weakness of the boiler. But observations on a considerable number of boilers, extending over a period of 20 years, have led to the conviction that, except in rare cases, these are the result of low feed or deficiency of water on the tube. The reasons which have led to this conclusion I shall briefly endeavour to show, and, if not generally convincing to the sceptical, the question seems open whether the subject is not worthy of further consideration on their part. Reference to the annexed outline or sketch of boiler on its seat or bottom flue will probably assist to render the matter plain. In a former note attention was directed to the fact of boilers being set 1½ in. and 2 in. lowest at the furnace end. Little remains now to add, except by way of illustration.

It might be remarked here that the first plate at the end of the boiler next the furnace-door is seldom exposed to a very strong heat, in consequence of the entrance of air, and the fire itself drawn so rapidly towards the bridge, indicated by the flight of arrows. This fact should be noticed when statements are given of the tube being uninjured over the furnace, one plate not being exposed to the direct action of the fire. Over the bridge at *E E* seems to be the point most exposed to intense heat; there the flame rushes through a small space, and, so far as my observation extends, this is the point at which collapse begins generally.

If we take the boiler at 36 ft. long, having 6 ft. length of furnace, it will be seen that 30 ft. of the length of tube has been gradually softened by heat; but when the water has receded thus far the iron, in some cases, over the bridge has been brought up to welding heat, and no reader of the Journal need be reminded how comparatively easy a tube well heated for 30 ft of its length can be crushed down, compared to the same length of tube cold or covered by water. The writer does not attempt to handle the subject scientifically for sufficient reasons, one of which is that, if need be, he can handle the shovel to "fire-up," and watch its effects on iron and water, and, as a result of experience, gained sometimes at much personal risk, the conclusion arrived at is simply that, with a full supply of feed and the tube free of incrustation, it must be a bad Cornish boiler that will not stand a working pressure of 40 lbs. to the inch, whilst a deficiency of feed in the very best constructed boiler, with a heated tube under this pressure, renders it liable to collapse at any moment.

A few years since, in the vicinity of Philadelphia, U.S., a case came under my notice:—A Cornish boiler, nearly new, which was built of best Low Moor iron, the plates being ½ in. thick, was apparently on the point of collapse, six or seven seams having been started, and rivets elongated, or partially drawn. An examination of the boiler immediately after the mishap showed the water to be 4 in. below the back of the tube, and where the water had left the iron exposed the scale or deposit was taken off very clean, giving it, in fact, the appearance of new iron, while the portion of tube which remained covered with water retained the incrustation intact. Since then, when opportunity offered, the writer has examined cases of collapse beyond the bridge, and in such case invariably the scale was removed from the back of the tubes in the same manner. Two or three instances might be given, which occurred about four years ago—One at Wheal Uny Mine, near Redruth, Cornwall, boiler of winding-engine; one at North Crofty, near Camborne, Cornwall, boiler of winding-engine; and one at Great Wheal Fortune, near Helston, Cornwall, boiler of pumping-engine; showing most conclusively that there was a deficiency of water in the boilers at the moment of collapse; but, from the evidence adduced at the time, and reported in the local papers, it was made to appear that each of these boilers exploded from inherent weakness, and not want of water, because three, or possibly four, plates were not crushed down over the furnace. This is a dangerous fallacy to propagate, and renders enginemen, to some extent, careless when such a doctrine gains credit—*i.e*, that boilers might "blow-up" (that is the local term) at any time. But select any number of practical enginemen, and put the question to them if they are afraid to work their boilers when their feed is up, supposing their boilers to be moderately good, and their answer will be, no. But ask them under other circumstances, say when the feed is "scattering" at the bottom cock—(the term "feed scattering" is used by enginemen and working engineers when the water has run so low in the boiler as to blow out much steam and just a little water when the gauge-cock is opened)—and of this they are fully aware that the feed scattering is quite dangerous enough, and too often only a prelude to the boiler itself being scattered, with its surroundings. There are men, however, so reckless as to work their boilers when there is not the least trace of water from the gauge-taps, choosing to risk the chance of getting up the feed again, and, of course, at the risk of their own lives, to the chance of being fined or discharged from the works.

Then place the matter on its proper basis, and when moderately good boilers collapse beyond the bridge say it is occasioned either by want of feed-water, undue loading of the safety-valve, or incrustation on the back of the tube. Each of these contingencies are easily preventable, and to practical men it is obvious that all enginemen, engineers, and agents should be awakened to the fact that boilers, as a rule, do not blow-up without neglect on somebody's part, and, so far as the enginemen are concerned, it will have a tendency to make them more careful of their own lives, and of the property entrusted to their charge. But, in the meantime, mine owners give your men appliances to blow off scum from the surface of the water, also the sediment from the bottom of the boilers, with a simple float and whistle to give alarm when the feed, from neglect or sudden leakage runs low, and to which might be added advantageously a water-gauge, with occasional opportunities to clean and examine the boilers, which will be conducive to safety and economy.

Engineers seldom put forth claims to infallibility—the writer especially owns to be very fallible, and on that ground he begs to be corrected in any mistaken views here enunciated.

Unhappily, "subjects" for examination are too often furnished by Cornwall. Let us hope that it will not average one boiler per month; but, at all events, if what is proverbially everybody's business could be concentrated, and facts and data collected from each explosion by competent inspection, and a record of the facts published in these columns, it would be serviceable to the world in general, and to Cornish mining in particular. A. R. R. O.

Norway, March 22.

OUR COAL SUPPLIES.

SIR,—In the notice of my lecture, inserted in the Supplement to the Journal of March 26, the reporter has made one or two errors which need correction. I did not say that the *lower* bands of coal (anthracite) in Devonshire belong to the Carboniferous system, as the lower Devonian has no coal but must be classed with the true Devonian. It is only the upper division of the Devonian rocks, as I stated, which are referrable to the Carboniferous series. The anthracite is worked in the neighbourhood of Bideford, the best averages nearly 4 ft. in thickness, while in some places it amounts to 20 ft. The fossil plants which occur in these Carbonaceous beds are all identical with those species which are most abundant in the coal fields of the central counties of England and in the South Wales basin. There is much difference of opinion among geologists about the true age and position of some of the rocks in Devonshire, and the strata are so much altered and contorted that there is great difficulty in deciding their true geological order; but the general opinion is that the upper division belongs to the Carboniferous, and the lower to the Devonian, or Old Red Sandstone. As regards coal basins, I did not say that there were no true coal basins properly so called. The Forest of Dean coal field, for instance, as I remarked, affords the best instance of a coal basin in England, and there are others, though not so well defined. But some coal fields give little evidence of being deposited in hollows of this kind. As many of your readers are, no doubt, geologists it is desirable that any radical mistakes should be removed, and I shall feel obliged if you will insert these corrections in next week's Journal. P. B. BRODIE, M.A., F.G.S.

Vicarage, Rowington, Warwick, April 1.

OUR COAL SUPPLIES.

SIR,—With reference to the remarks of Mr. W. Fairley, quoted in last week's Journal, I beg to say that with regard to the probable duration of the Staffordshire coal field, I based my calculations on the opinion of some geologists well acquainted with the district, who give 30 years as the probable time when it will be exhausted. But none of us took into calculation the new coal area round Sandrode Park, &c., as it has yet to be proved by actual working, and the extent and thickness of the coal seams, but it is most satisfactory to find that there is a probability of a larger area of coal being developed in Staffordshire. With reference to the South Wales coal field, I spoke with caution; Mr. Fairley gives 800 years as his estimate, and my friend, Prof. Hull, 2400 years, so that the time I assigned may be, perhaps, considered a very fair estimate. Unfortunately a great deal of the Welsh coal is of inferior quality, and unsuitable for domestic use. Of course, new areas may be opened up, but 1000 years is a long time to look forward to, and I can only say that I hope it may be ultimately found that we shall have an unlimited and unfailing (which I think is very doubtful) supply. I am not an alarmist with regard to the duration of our coal, but in due time all our old coal fields will be worked out, and although new ones, or rather, further extension of old ones, may be discovered in the British isles, even these must, after awhile, be exhausted, and I cannot, therefore, agree with Mr. Fairley when he says that our supplies of this mineral will be a *never*-failing one. No doubt many coal fields will be found in other parts of the world, but the expense of carriage would render the coal so costly that it would practically be unavailable. It will be an unhappy day for England when we have to depend upon foreign countries for our supply of this valuable and important mineral.

P. B. BRODIE, M.A., F.G.S.

Vicarage, Rowington, Warwick, April 4.

UTILISATION OF REFUSE SHALE.

SIR,—As the utilisation of shale for the production of an oil that could be used as fuel for the generation of steam would be of considerable advantage in economising our coal, it will no doubt be of interest to many readers of the *Mining Journal* to learn that much of the shale now wasted will well repay the cost of manipulating it. I forward herewith a small sample of the crude oil I extracted from a small quantity of shale, or what is locally called batt. The sample operated upon had been out of the pit 14 years; and from what I have heard and observed since I have been in this neighbourhood, I am satisfied there is a vast amount of oil-producing shale thrown away which, if utilised, would become a commercial good to the country.

I am not yet prepared to say the exact yield of these shales, but am willing to arrange with parties to test practically at the works in Flintshire any quantity (say, about 2 tons) which I consider sufficient to give a true result, so that the exact value may be known. Retorts may be erected here or elsewhere at a very small outlay, as I am prepared to show to any party who feels interested in the matter. Colliery proprietors who have this shale in sufficient quantity would find it very desirable to erect retorts convenient to their pits, so as to extract the oils on the spot. The labour required for 12 retorts, which would use up 9 tons of shale in 24 hours, would be four men; of course the quantity of oil would be according to the yield of shale, The sample forwarded has been produced at a great disadvantage, having been extracted with a small retort in my house fire, and will, therefore, be inferior to that which would be obtained in properly erected retorts.—*West Bromwich, April 6.* E. G. BUTTERY.

COLORADO, AND ITS MINERAL WEALTH.

SIR,—In my communication of Feb. 26, which was published in the Supplement to the Journal of March 26, I promised to give you more information on mining in Colorado. Ten years ago, when the white men first entered here for the purpose of gulch mining, they commenced at North Clear Creek, then extended their mining up into Russell's Gulch, which was found to be very rich both in gold and silver, then continued their mining home to Illinois Mountain, in Central District. In the course of a distance of ten miles a number of lodes were discovered. Russell's Gulch is bounded on the south-west side by a range of mountains that contain a number of rich lodes, both gold and silver, but principally silver. On the north-east side of the above-named gulch is a range of mountains, which divides Russell's Gulch from the Gregory Gulch. These mountains contain a number of rich lodes, also both gold and silver. In consequence of these lodes being intermixed with a large quantity of silver and sulphide of iron, the quartz at present cannot be treated to advantage in the stamp-mills. By that means the greatest portion of the

mines in Russell's Gulch are abandoned, although rich; but when different appliances are erected here for the treatment of this class of ores I have not the least doubt but they will be re-worked, and, if re-worked by companies, they will be found, in my opinion, some of the richest mines in the world. This district is, as other districts in Colorado, very much in want of furnaces to smelt the ores which cannot be treated in the stamp-mills that are now in operation. I am informed that Mr. R. A. Old, a gentleman who has paid great attention to the mineral wealth of Colorado, is now in England for the purpose of inducing English capitalists to erect furnaces. It is to be hoped he will succeed, as it will be a safe investment for capital, and not a speculation. No men can give better information respecting the mineral wealth of Colorado than Mr. Cope, of Bartholomew House, London, and Mr. R. A. Old: the country is well known to them, and every practical man in Colorado is aware there are thousands of tons of very rich ores—gold, silver, copper, and lead, and not a market here for them.

I could furnish you with the particulars of a large number of the mines in Russell's Gulch, and the quantity of gold and silver the lodes contain per ton; but as I do not like to occupy too great a space in your Journal I must send the information occasionally.

Enterprise—tunnel driven 40 ft.; shaft sunk 32 ft.; lode, 2 to 5 ft. wide, with a leader 2 ft. wide; assay, by Prof. Burlingame, gives $1300 in silver, and $80 gold per ton; yield by amalgamation $125 silver per ton.

Minesota Mine—shaft sunk, 60 ft.; lode, 8 ft. wide, with two leaders of rich ore, 6 in. and 8 in. wide; assay, 20 ft. deep, gives $10, 30 ft. $18, 40 ft. $29, 50 ft. deep $40 per ton gold; character of ore, iron pyrites and free gold quartz.

Pewabic Mine, Russell district—shaft sunk, 100 ft. deep; lode, 7 ft. wide; yield, $50 to $60 per ton gold; does not treat well by stamps; character of ore, iron and copper pyrites, and sulphuret of silver.

Nevada district is now attracting great attention: here there are a number of mines, or what we term claims, at work, and others starting up daily. The lodes are very rich, and easy to work. The ores are found to treat better in stamp-mills than some parts of the district. The lodes in Flack Mountain, on an average, will yield over 2½ ozs. of gold to the ton of ore. The greatest part of the mines or claims about Nevada are leased to miners for twelve months or two years, provided the property is not sold; then the miners who lease it must have six months' notice, as a Yankee is always open to sell his property, let it be as rich as it may. When I speak of leasing a mine, it is just the same as tribute in mines in Cornwall: the men who lease the mines have to pay about one-fourth of the gold raised to the proprietor. By that means the mines are not opened and worked in a miner-like manner, as they would be by good companies. I hope to see joint-stock companies start up, as, in my opinion, they will find Colorado one of the richest countries in the world, and one of the most profitable in which to invest capital: the richness of the country and the advantages for working mines warrant it a safe investment for capital, and free from risk. THOS. JENNINGS.

Central City, Gilpin County, Colorado, March 14.

RHENISH PRUSSIA—No. VIII.

DUES ON THESE MINES ONE-FIFTIETH ONLY!

SIR,—Notwithstanding the limited number of articles communicated through the *Mining Journal* on the mineral wealth of this district, these articles have resulted in very extensive operations on the very mines pointed out by me.

First, the St. Josephsberg, the subject of my first letter, so long ago as May, 1867, has, in consequence of that communication, been set at work by a company with 30,000*l.* capital, all the shares well held, and is returning very large quantities of mineral, with the certainty, under good management, of immense dividends. One lode has been valued by *more than one* of our best Cornish agent as worth over *two hundred pounds sterling* per fathom, and the seven lodes reported on specially by the toller to the King of Prussia cannot be estimated at less than *three hundred and fifty pounds sterling* in the aggregate. The lead lode is also large and rich for silver, and the blende lode is also very productive. So much for St. Josephsberg, which has only attained the depth of 50 fms. under adit, and has been for centuries one of the richest copper mines in Europe. Its two drawing-engines are at work. The 60-inch cylinder engine, now being erected by the Messrs. Nicholls, Mathews, and Co., of Tavistock, will be ready for work on April 10, as well as the stone-breakiug, crushing, and dressing apparatus. The acid reducing works are in full operation. The Company need fear no fall in the price of metals, as a very large portion of the copper ores exceeds 25 per cent. produce, and the poorer ores, being carbonates and phosphates, can be returned at very large profits by the acid process; *whilst the lead is rich for silver*, a point too much overlooked by the investing public. This sett, with a recent extension, comprises about 150,000 square lachters.*

Second, Mensenberg.—This sett is about 2½ miles long, and 1¼ mile broad. Here are *nine* of the finest copper lodes, *two* lead lodes, and *one* blende lode. The main copper lode is officially reported by Freiherr von Huene, the toller to the Prussian Government, to be 27 ft. wide, being one of the St. Josephsberg lodes; the others corresponding with the lodes in that mine, imbedded in the same great channel of spar. These lodes at surface contain carbonate, malachite, red and black oxide, and yellow and grey sulphurets. This sett contains all the St. Josephsberg and Marienberg lodes, which two mines have for centuries been celebrated as amongst the most profitable in Europe. Also several caunter lodes, and two lodes of lead and blende, not known in these setts. These mines will shortly be before the public. This sett comprises 500,000 square lachters.

Third, the Rhine Mining Company (Limited).—What's in a name? Certainly those gentlemen have an *extensive* name for their mine. This mine lies to the south of St. Josephberg, and contains all the north and south, or main, lodes of those mines, with a course of ore worth, according to the official report, at least 150*l.* per fathom, within 100 fms. of its northern boundary, *and this shute is dipping south.* It has four lead lodes, two of which have been extensively worked. The company, facetiously called by one of your contemporaries, "The Pilgrims of the Rhine," have commenced their work in earnest, by the sinking a good shaft between the lodes of Toni and Schmelzer, which even at 14 lachters under surface were profitably worked. *Gluck Auf!* Success to their pilgrimage.

Fourth, Marienberg has been recommenced with vigour, and more team is at once to be clapped on. More on this anon.

Clementslust.—This mine has been reported on by Mr. David Forbes, F.R.S.; Capt. Thomas Trevillian, of Herodsfoot, Liskeard; Capt. Thomas Rickard, late of the celebrated Pontgibaud Mines; and Obersteiger Mühlenbein, manager of the St. Josephsberg Mine, in terms which amaze one; but still they are cautious reports. The mine itself is only 27 lachters, has made large profits, and the *ores above the deep level were more than a year since* officially reported by the King of Prussia's toller, Herr Mühlenbein, of St. Josephsberg, and Herr Marcheider Schwartze as worth 100,000 thalers, and the mine is rapidly improving in depth. The copper ores are very rich in quality. The lead lode has only recently been opened up, but is large and very productive, and contains about 26 ozs. of silver to the ton. This mine has been purchased, and will be brought before the English public at a price which will at once pay 15 per cent. per annum on the capital from ores already discovered, whilst the profits at the expiration of two years must exceed 100 per cent. The sett is about two miles long on the course of the main copper lodes, and one mile wide on the great silver-lead lode.

Phœnix Lead and Silver Mines.—Fifth, last not least, in my this week's report is Phœnix. Here the lead lode is immensely rich, worth 100*l.* per fathom. The blende is also rich, and the lode having been discovered on both sides of the two cross-courses which formerly appeared to bound it, *no limit can be fixed as to its value.* There are three steam-engines for pumping, hauling, and drawing, each of sufficient power to carry out the works of a large mine, and in good repair. All that is here required is vigorous management. The mine, which adjoins the celebrated Ludrich Mine, the property of the Vieille Montagne Company, extends over an area of about two million square lachters, and in which are several lead and blende lodes, cropping rich to surface. For this a company is being privately formed, to pay on the capital 12 per cent. from ores already laid open.

* A lachter is 6 feet 10½ inches.

This district has become so important only for the size of its lodes, the high produce of its ores, the richness of the lead for silver, and the purity of the blende, and the fact that the dues are only 2 per cent., so that the shareholders have the profits instead of the lords, that I propose to continue these communications at least fortnightly. In Prussia the miner makes large profits. The mines are *shallower and drier, and the dues are* 1-50th *only.* OUR CORRESPONDENT.

April 5.

MINING IN PRUSSIA.

SIR,—Since 1867 the Prussian Government use every effort to draw capital into mining in that country. 1. The capitalist has the advantage of the advice and experience of the best miners that the kingdom can supply, *free of all charge.*—2. These agents report to the Government monthly, a duplicate being left on the mine for inspection. "Cooking reports" is an impossibility.—3. The mines are shallow, the water little, labour abundant and cheap, and roads good. —4. The poorer ores, occurring mostly as phosphates and carbonates, are reduced by muriatic acid to 70 or 80 per cent., all above ¾ per cent. being profit. The richer ores occur in leaders, easily separable underground, and average 25 per cent., the Cornish ores not averaging over 7 per cent.—5. The lead ores are rich for silver, and particularly free from impurity, and in such mines as Ludrich, the Ems Mines, Alter Fritz, Phœnix, &c., sell with very little dressing at 15*l.* to 16*l.* on the mines, the average of Welsh mines not exceeding 12*l.*—6. The lodes are remarkably regular and continuous.—Lastly, the mines are held in perpetuity, at 1-50th, or 2 per cent. royalty, whilst British mines pay an average royalty of 1-50th. This alone is sufficient to account for the fact that Prussian mining is so vastly more profitable an investment than British mining. ANGLO-PRUSSIAN.

RHENISH CONSOLIDATED MINING COMPANY.

SIR,—Let your correspondents, "A Shareholder" and "Y," direct their attention to management on the Bleibach Mine, and the raising and dressing the ores. The lead occurs in leaders, as well as diffused throughout a large lode mixed with spar and country. Should these leaders of lead be separated *underground*, and sent without dressing, beyond mere hand picking, to market, and the poorer ores be separately dressed? Should not the shaft be sunk more rapidly? Cornish agents when abroad are apt to fall into the lethagic ways of foreigners. Wake up your agent. Your representant is an honest man and a gentleman, and will second your efforts. The carriage from these mines, as well as from the James Watt, is rather heavy, but the dues being *two per cent.* only, and the ore lead, this is not very important. A WELL-WISHER.

GOLD IN NOVA SCOTIA.

SIR,—We received last night the following intelligence:—

Halifax, N.S., March 25. F. N. GISBORNE.

March 24.—Fifty tons of quartz from the Gisborne Mine, Isaac's Harbour, have now been crushed at the Mulgrave Mill, and have yielded 73 ozs. 12 dwts. 7 grs., or an average of about 1½ oz. per ton, without selection. This mine is *held*, not offered, at 20,000*l.*; and should the master lode, 21 ft. wide, which runs through the property, continue to give even one quarter of its present yield of gold, it will still be held at its present valuation by the "United Mining Association of Nova Scotia."

MONTE ALBO MINING COMPANY (LIMITED).

SIR,—I observe that in this company 12,800 A shares are advertised to have a preferential dividend of 15 per cent. before the vendor's B shares get any dividend at all, or before any royalty can be paid to him, and that in case there is not sufficient profit in any year to pay this 15 per cent. to the A shares, the deficiency shall be paid out of the profits of any future year before any dividend can be received on the B shares, or any royalty.

If this is correct, and from the known respectability of all the directors, there can be no doubt about it, surely the holders of all these 12,800 A shares will be in an unusually favourable position, as the produce of the mines for the present year is stated by the eminent engineer, Mr. Bewick, to be above 6000 tons of lead ore, equal to a clear net profit of 30,000*l.*, which, after paying the preferential dividend of 15 per cent. to the A shares, and afterwards the 15 per cent. on the B shares, and the royalty of 1*l.*, leaves a balance of 9000*l.* a year, which, with the preferential dividend of 15 per cent., makes a clear net profit of 24 per cent. on the A shares. J.

PATENT PANACEA.

MR. MACFIE'S SUBSTITUTE FOR PATENT LAWS.

SIR,—I have often heard it doubted whether Mr. Macfie, M.P. for Leith, is really in earnest in the views he has published on the subject of "Abolition of Patents," and which he supports in all of his speeches in public. Out of mere curiosity, I went on Thursday, the 31st March, to the Inventors' Institute, Trafalgar-square, to hear the honourable member's communication "On the Substitute for Patent Laws," as suggested by him in his before-named work. Having carefully read his book, which I found to be full of contradictions, misstatements, and impracticable schemes, I hoped I should be enlightened by hearing its author propound views of a more comprehensible character. I must say that he was listened to with profound attention, and his extraordinary and extravagant statements were received and reviewed with all possible candour and consideration; but anything more absurd I cannot conceive it possible for any sane man to promulgate. He referred to pages 84, 85, and 86 of his publication, from which he read his "New System of Rewarding Inventors, and Promoting the Publication of Inventions," commenting on each passage as he proceeded. The grand feature of his scheme consists in the mode of rewarding "*meritorious* inventors," for none but meritorious ones are to be rewarded, and these are to be selected by competent persons in the several trades and professions affected by the novelties to be introduced! Thus the cotton spinner, the ironmaster, the tanner, &c., are to approve, commend, and recommend for reward any inventions that will render null and void any of their old machinery and processes; nay, their voice is to settle the justness of the inventor's claim, even though the inventor's scheme should supersede some of their antiquated processes of manufacture! Assuming, then, that these trading philanthropists report favourably, then, and then only, is the "*meritorious* inventor" to be, if in the—

1st rank,	entitled to a reward of	£10,000
2nd rank	" "	5,000
3rd rank	" "	1,000
4th rank	" "	500
5th rank	" "	100
6th rank	" "	50

After which follow "meritorious inventors" of the 7th, 8th, and lower ranks, who can only be distinguished either by gold, silver, or bronze metals, or by a certificate of merit. As affecting himself, Mr. Macfie very complacently declared that he would prefer the Queen's medal to any amount of money; but, at the same time, he acknowledged his having heard it said that "medals would not make the pot boil."

Mr. Macfie particularly noticed that patents were an "exclusive privilege," affecting three important interests:—1. The master manufacturers.—2. The workmen in their employ.—3. The public, the great consumers. But he entirely failed to show the remotest *disadvantage* that patents had on these classes of the community; while it was argued, in opposition to his assertions, that manufactures prospered, that labour of all kinds was in greater demand with than it would be without the improvements and the new manufactures which were constantly being introduced by patented inventions; and that of all classes the public were especially interested in the cheapening of manufactured articles as effected by advancement in invention. It was likewise argued, in opposition to his statement, that it would be unjust to tax that portion of the public that had no direct interest in certain patents which would have to receive Government rewards, such as for cannon, arms, shipbuilding, metallurgy, &c. And still stronger arguments against any system of Government rewards arose from the fact that of all such rewards hitherto given there is not one on record that can be shown to have been justly rewarded, or to have proved a public benefaction; besides which, it is against all past experience to believe that if manufacturers were, through the adoption of Mr. Macfie's "New System," relieved of the inconsiderable tax which they pay to patentees by way of royalties, that the public at large would receive any considerable benefit from the cheapened processes thus introduced. All experience teaches the public that no sooner is any duty whatever taken off articles of general consumption than the manufacturers and traders, and *not* the public, reap the chief advantage from the removal of such restrictions. It is very certain that the lessening or removal of existing excise duties affecting brewers would have no effect to lower the price of beer; or certainly not until after a period of time far exceeding the ordinary patent term of 14 years.

Mr. Macfie's object would appear mainly to be the offering of some means for doing away with monopoly (as he calls it) in Invention; and introducing a system of free trade in other men's ideas! With this grand crotchet ever present in his mind, he sees no limits to "free trade," just as some infatuated men see no limits to "independence." Mr. Macfie can set no bounds to free trade. Everything is to be open to everybody. Nothing is to be sacred. Inventions are but ideas, and he cannot understand that there are differences in ideas. Perhaps he can comprehend that one house refines sugars more economically and better than another; or spins yarns, weaves cotton, worsted, or silk goods better than another; but as to ideas—the ideas of a Watt, a Smeaton, or Arkwright are not a groat better than the ideas of Smith, Brown, or Robinson!

The senselessness of Mr. Macfie's arguments—or, more properly, his assertions—consists in this, that he cannot distinguish between a grain of wheat in the grainery and an ear of wheat in the wheatfield; or between a crude idea in an ignorant head and a matured idea in a wise head. Thousands of men have an idea that the diamond is no more than carbon, or charcoal. Therefore, if any man should find out a method of converting carbon into diamonds, Mr. Macfie would demand to share in his invention, on free trade principles! In the sama way, if any man should invent a means of employing the elements of water as a fuel obtained directly from water, Mr. Macfie would step in with his freebooting principle, and although the invention might cost a lifetime of study, and the expenditure of a fortune, Mr. Macfie, with his committee of coal mine proprietors, would (of course) award to such a "meritorious inventor" the "first reward of 10,000*l.*," as affording ample and sufficient remuneration.

Mr. Macfie has entered an arena in which he cuts a very miserable figure, from sheer incompetence to grapple with the subject in hand. No common provincial debating club could show itself less informed, or more incompetent for the task that he has undertaken, than is exhibited in his books, pamphlets, and speeches. Anything more thoroughly amateur-like it is impossible to conceive. He puts history and experience entirely out of the question. The last 200 years are as nothing so him; the history of progress he discards altogether; and as regards recent improved patent laws he not only shuts his own eyes to them, but demands that all who listen to him shall do the same. Thus prepared, he stalks forth into a new arena, garnished with all the frippery of his fruitful fancy.

From and after the fulfilment of his "New System" we may hope that instead of only about 3000 inventors per annum the number will be doubled or trippled, and among the "meritorious" ones will have to be distributed a sum total of 16,650*l.* as rewards, and to the less "meritorious" medals and certificates. There might be a sufficiency to pay each 5*l.* 10s.! If, as was observed at the meeting in the discussion, the object were to equalise reward to inventors such a system might truly have the effect to give something to many who at present reap nothing.

This subject is not, however, to be passed over lightly, and a word of advice to Mr. Macfie may not be thrown away. He plainly shows himself to be the mouthpiece of the manufacturers. All his statements are in their favour, he never breathes a word in respect to advantages to be derived from the introduction of his "new system" by the working classes, or by the public. All his sympathy with inventors is proffered in a tone too affected to obtain their esteem, for he shows himself incable of estimating their value in promoting the progress of arts, of manufactures, and of civilisation generally. The Janus character is very difficult to sustain under any circumstances, but the wit and intelligence of the class he endeavours to cajole with his crude, untenable theories and system is acutely opposed to his shallow dogmas, although upheld with all apparent sincerity. The time has arrived for him to be more outspoken, to declare himself the sole advocate of the cause of manufacturers, and the uncompromising enemy of patent law, patentees, and the entire community of inventors, as innovators, whose sole object is to revolutionise old trades and the invested rights of manufacturing interests.

London, April 2. INVENTOR AND PATENTEE.

METALLIC MINING.

SIR,—It is encouraging to the metallic miner to see the great influx of capital that is being embarked in mining enterprise at the present time. Gold and lead mines seem to be in special favour, which is natural, when we consider that in the working of these particular minerals adventurers have been peculiarly fortunate; thus we find that good mines act as a magnet, attracting capital in profusion to those districts that are pre-eminent for their wealth. There are, no doubt, many other mineral districts in these islands that are well worthy of more attention than has been accorded them hitherto, but which, labouring under removable disadvantages, have never attained, or do not now reach, that prosperity that their merits deserve. That there are very many mines scattered over the country which ought to be successful concerns, but are not, simply through some certain hindrance, or a combination of these, is patent to all who have given the least attention to the subject. I have always, and do now more than ever, feel that the cause of most mining failures is to be ascribed more to defective and improper working of mines, rather than poverty of lodes.

It is painful to witness the position of many real good mines, which, although verging on, and entitled to the Dividend List, never reach that wished-for goal, in spite of anxious application on the part of directors, who fail in all their remedial measures, simply through ignorance to the last of the real drawback. One obstacle to success is to be found very often in the appointment of managers strangers to the strata in which the mines are situate, who, disregarding the peculiarities in the way that the ores are deposited, which must be studied, understood, and attended to, to ensure successful results, set to work in the method that they have been accustomed to heretofore, without reference to its applicability in their new sphere. Nothing is more surprising than the cool way that past experience is ignored and totally repudiated by many, who, shutting their eyes to obvious facts, and their ears to dictates of common prudence, blindly rush from the known to the unknown, and pretending to see good reasons for their procedure in indications that nobody else can understand, eventually add another to the many examples of the danger of neglecting to study the effect of a change in the enclosing rock or veinstone on the metalliferous contents of the lode.

In such an uncertain thing as metallic mining, actual exploration is, strictly speaking, the only reliable data; and even in districts where all past working has demonstrated hitherto that the runs of ore, which might almost be called continuous in the shallow levels (meaning by that term down to about 40 fms.), embedded in ground of an easy character for working, shorten in length in regular ratio as depth is reached, and yield less quantity in harder ground. I repeat, that even in these discouraging circumstances it is desirable to obtain certain evidence whether the ores are to be had in sufficient quantity in depth to pay for the vastly increased cost of working, necessitated by the harder ground, and heavy engine charges incurred working below adit; but in instituting an experiment of this magnitude, common sense would dictate that it should only be regarded as such, to be carried out only as the claims of other necessities, and the disposable capital at command will allow, while the strength of the mine is concentrated on ground the capabilities and character of which has been proved. To the want of caution in this respect, risking all on unseen probabilities, there is, unfortunately, a proneness on the part of those in charge of mine interests which is of the most hurtful kind to the success of many first-rate investments.

The careful manager will devote much thought and study to the facts that have accumulated and are recorded in the past working of the mines in the district where he is located, before he induces those who rely on his advice to depart from the, at least, safe inferences of profitable working for, perhaps, upwards of a century, to depend on a new theory that must, until substantiated, be regarded as a costly trial, to call it by the mildest term. Were this reasonable system, of energetically making the most of the certain, while carefully and economically testing the doubtful, acted on more generally

the hazard of mining would be reduced to a minimum, and success would crown labours which are now, and must be, resultless for good, because unsuited to the requirements of the case. Plausible reasons are, indeed, often advanced for adopting a different policy, which, if an improvement on the meretricious phraseology so common in the reports and on the lips of some, mean nothing, but which, by their speciousness and glitter mislead. But I have little inclination to give heed to any arguments that would set aside the groundwork, in the shape of sections of the old workings in the mine, showing the extent of ore ground in different levels, detail of produce, and cost of extraction, &c., from which useful generalisations can only, I submit, be drawn, to indicate the probable future of any mine.

Caldbeck, April 5. W. GIBSON.

GAS AT THE VAN MINE.

SIR,—Seeing in last week's Journal an enquiry as to the gas at the Van Mine, I would suggest that if your correspondent would write to Mr. William Lefeaux, Llanidloes, he would, no doubt, give the information he seeks, he having some 26 years ago commenced operations in that district, at which time not a single mine was at work in the neighbourhood, and I am told at the very outset he met with nothing but ridicule from those who were supposed to understand the district best. Following, however, only the promptings of a widely-acquired experience, he purchased in one sett Bryntail (now Van Consols) and Penclyn Mines. On commencing operations at the latter mine he at once discovered a bunch of ore, from which it is understood he realised a profit of from 40,000*l.* to 50,000*l.*; but, meeting with adverse influences, he abandoned it. The lode now called the Van lode having been found to be of such a masterly character, he, in conjunction with two or three others, commenced operations at the Van—in fact, it was he who started the deep adit. Owing, however, to some disagreement with his co-partners, he left them, when they also ceased to carry on the deep adit, and for some years restricted their works to the surface, without any beneficial results. As a last resource, the deep adit was taken up again, and by its means one of the finest and richest lead mines in the United Kingdom was shortly, and at a very small cost, laid open. To the east of the Van, and within a few hundred yards of that mine, in what Mr. Lefeaux's experience of the district made him believe would prove eventually to contain the richest and most lasting part of the Van lode, he again commenced operations, and, as far as can be seen, with every reasonable prospect of success—this mine is called Glangwyden. The extraordinary but very distinctive feature of the Van lode is that it gives off a large amount of inflammable gas; it has been found to a great extent at the Van, and, to use Capt. Williams's own words, "When the gas and water disappear from the Van you may say good bye to the mine." At Penclyn traces of it were to be found, but at Glangwyden the lode gives off a larger quantity, and this is considered a matter of great importance; it is, in fact, a most favourable indication. As to whether the gas proceeds from the mineral or the shale, I must leave that to more able writers than myself.

Llanidloes, April 5. J. W. B.

GAS AT THE VAN AND OTHER MINES.

SIR,—I observe in last week's Journal that one of your correspondents wishes to know what may be the probable cause of the escape of gas in Van, Pen-y-Clyn, and Glangwden Mines. I believe it has been hitherto unaccounted for, but I have an idea, which I think may be possibly correct,—there is no doubt that the gas evolved is hydrogen, and it occurs in connection with large deposits of sulphides of lead, zinc, and iron, and the water which bursts forth with the gas is slightly impregnated with sulphuretted hydrogen. May it not be that these metals when held in solution combine with the sulphur of the latter compound, and from the sulphides and the hydrogen gets free?—*April 5.* INVESTIGATOR.

BARYTES MINES.

SIR,—I have just discovered an enormous lode of Barytes upon an estate in South Devon, but as I happen to know more about the land department than the mineral I am advised to make it known through the *Mining Journal*. I send you a fair specimen, taken from the mass of ore in sight, which can readily be quarried out; and if not crushed by water-power on the spot, it could be put on the railroad (close by), and run down to the sea for shipment, at a very low rate. Such is the true outline of my discovery of the raw material. I must now ask some of your practical correspondents to tell me what to do with it, as also its properties, uses, and market value? Please place to the credit side that I will give your readers a wrinkle about land when placed in a similar position. A LAND AGENT.

April 6.

BARYTES MINES.

SIR,—I notice an advertisement to the effect that a large quantity of barytes can be raised at the Teign Valley Mine, in Devon. A friend of mine wishes to know more about this class of ore, and what its particular qualities are, and what it is used for? The company seems likely to prove very successful, especially if the lead mine is as promising as the Frank Mills Mine below. AN OLD SUBSCRIBER.

THE SOUTH ST. JUST TIN MINING COMPANY.

SIR,—It gives me great satisfaction, as an old miner, to see a property about to be resuscitated that was most unworthily neglected by its late proprietary—I allude to the South St. Just, the advertisement of which appears in your columns.

Now, it is seldom so truly a legitimate an affair is brought out; the circumstances are plainly and truthfully stated, and I believe, as the prospectus states, that in a brief period the mine will be a dividend property. It has been the surprise of all persons who know the locality that these lodes have not been more fully developed ere this; but the late depression in the prices of metals and ores undoubtedly was the principal cause; at present prices are such as to render complaint useless; if a mine cannot produce tin into the market to meet it, the ore had better be left in the lodes. It is to be hoped, for the sake of the district, that these mines will be placed under proper supervision, and that the capital proposed to be raised will be expended on the mine, and not in London offices, or too grand attempts to do the splendid. With economy I feel quite assured the mines will pay as well as any tin mines in Cornwall have. A large amount of preliminary work has been done, good and efficient machinery bought at a remarkably cheap rate, easy dues, and the paramount advantage of having water-power to work with. AN OLD MINER.

Penzance, April 5.

SHROPSHIRE MINING DISTRICT—No. III.

SIR,—The moderate amount of water met with in sinking in this district is certainly a great advantage. The Tankerville Mine, formerly the Oven Pipe, is drained by a small colliery engine; and the Round Hill was put down to the 90 by a single rotary engine, which also performed the whole of the drawing and crushing. Nor should we pass over the Shropshire miners, who are good workmen—not much inferior, if at all, to their brethren in Cornwall, and by no means addicted, as is too often the case in Wales, to sending threatening anonymous letters to the agents in case the pitches are not set to them exactly on their own terms. If the shareholders in some of the Welsh mines were thoroughly aware of this it would open their eyes somewhat, and perhaps induce them to work their mines entirely by Cornishmen. We do not assert this from mere hearsay, having on two occasions been shown such threatening letters by agents in North Wales. Nor will the public easily forget the conduct of the Mold rioters, a short time ago. It is, indeed, extremely difficult to manage these Welsh miners, especially in the case of an English agent. In conclusion, should any adventurer wish to visit the Shropshire district he will, by staying a few days at Minsterley or Pontesbury, be able to see beautiful scenery, and to find many objects of interest in geology, botany, and other kindred pursuits. J. B.

MINING IN SHROPSHIRE.

SIR,—With considerable surprise I noticed in last week's Journal a letter signed "J. B.," purporting to give a comprehensive sketch of mining in Shropshire, wherein the writer, who must evidently be but a superficial observer, states, amongst other inaccuracies, that the Rorrington Mine, which has been worked by several companies to a loss, owes its unproductiveness to its position—the strata being "uncongenial," quoting at the same time by way of contrast the Snailbeach Mine.

Now, it happens unfortunately for your correspondent's case that the Snailbeach Mine, which he lauds so highly, was also worked to a great loss by several companies before the present company, by their well-directed and practical efforts, brought its treasures to light; also that the Rorrington Mine, which is pronounced so authoritatively to be so "many miles away" and so "uncongenial," happens to be not more than three miles off, and upon the same lode as the Snailbeach Mine. This latter fact can be corroborated by both the late and present agents of the Snailbeach Mine, and by other practical and competent men who have carefully examined this mine, and whose reports are still in existence, stating that the Rorrington Mine, with but a small amount of capital judiciously applied, bids fair to become one of the best mines in the county of Salop, there having been already great quantities of sulphate (not carbonate) of barytes sold from it, as also from Snailbeach and other mines in the district.

Happening to have known this property for the last 20 years, I lose no time in replying to "J. B.," whom I challenge to substantiate his statement, and also solicit to append his name to any future communication he may make on this subject to the Journal, should he choose to enter into a correspondence on the matter.

JAMES RICHARDS.

South Van Mine, Llanidloes, Montgomeryshire, April 7.

CRENVER AND WHEAL ABRAHAM MINES.

SIR,—In the midst of some discouragement, consequent on the reduced price of copper ore, it is pleasing to find that several mines of good promise are to be re-worked with energy. Amongst those that might be named Crenver and Wheal Abraham, in Crowan, Cornwall, are the most prominent. About the year 1864 a company was formed, or partly so, to re-open and explore these extensive mines, which 40 years previously, were suspended, after yielding copper ores of about a million sterling in value, and giving large dividends. The company who reaped the fruit of that working on copper entirely overlooked the *tin*, of which it is said considerable quantities were stowed away in the stulls as "deads." Now that tin is at a good price, doubtless all those stores will be made available to the present proprietary, who, I understand, are about to work the mines in a miner-like manner. If they do so, I have a full persuasion that dividends will be resumed. The plant on the mines is of the very best description, and ample for commanding the drainage 100 fms. below the present bottoms. I believe that the diameters of the cylinders of the three pumping-engines are 90, 80, and 70 inches, respectively, and there are several drawing and capstan engines also on the mine, and every kind of material requisite for an effectual working. The contractor, a London gentleman, who failed in business during the progress of the erections, led to the stopping of the works in 1866, whereupon Mr. Humphry Willyams, who had confidence in the character of the mine, and who had advanced money on the property, took possession, and carried on operations at his own risk, till a company was formed for a more effective or extensive working. I am happy to find that such a company has been formed, of a most respectable kind, who recently held a meeting in London, which was well attended, and when resolutions were passed to carry on the operations under the management of Captain William Kitto. The company is registered under the Limited Liability Act, and the offices are at 15, New Broad-street, London. I am informed that most of the shares are appropriated. R. S.

EAST WHEAL LOVELL MINING COMPANY.

SIR,—I am one of those hapless individuals who credit statements made by those who have to depend upon their reputation for their subsistence. Hence I am in that lugubrious category of one who, after perusing the "special" report of Capt. Harris upon this mine, which appeared in the Journal a fortnight since, proceeded in "hot haste" to my broker, with imperative instructions to purchase an interest at about 30*l.* per share, pinning my faith upon the unequivocal statement of that "well-known practical authority," "that the day is not far distant when the shares will be from 35*l.* to 40*l.*" By some fatuity which I cannot understand, from the very moment that unmistakeably "bullish" opinion was expressed the price gradually but surely declined, until, instead of being 35*l.*, the shares were 23*l.* sellers!"

My more immediate object, however, in addressing this communication is to protest against the growing tendency on the part of mine captains to express opinions, not so much as to the position and prospects of a mine as "to what the shares are going to." I hold that a purely disinterested and unbiassed agent—and I suppose there are such beings—should scarcely know that the property they are called upon to inspect has a market existence, or, at any rate, should never so far forget their calling as to be self-deluded into a belief that they are prophetically gifted as to the future market value of any share. For their reputation sake they should ever remember that their province is the mine, not the market, and that the whole of their speculative theories as to what price any particular share may advance or decline may be entirely upset by a "weak bull" or an "over-bearer" account. To all such I would commend the well-known proverb—*Ne sutor ultra crepidam.* OBSERVER.

April 5.

[ADVERTISEMENT.]

VIRTUOUS LADY MINE.

SIR,—Mr. Barnard, in last week's *Mining Journal*, amongst other things, says—

"I have repeatedly, and from the very formation of the company, given my opinion that it was absurd to suppose we were going to find wealth in the old workings."

Now, without any comment, I would wish to compare this statement with his reports of the following dates:—

Nov. 25, 1869.—"This is, indeed, a marvellous mine, and is fast getting beyond my weak powers of description, and I am entirely nonplused for language to keep pace with the extravagant remarkableness of the case. In five different places we are working in copper, and as yet we have not made what I call a real start; this is simply a wee bit of introductory."

Nov. 26—*(Telegram).*—"Another entirely new discovery; blasting down half-ton rocks of *solid* richest ore. Shares to-day 3*l.*, worth double."

And again, in January—"Every pitch set is looking well. Hawke's lode, the great discovery, is richer than ever. Yesterday a branch of solid ore was discovered, independent of the splendid course of ore already laid open. There is no prediction here. Do I lie? Let my enemies come forward and say that I do."

April 4. OBSERVER.

[For remainder of Original Correspondence, see this day's Journal.]

FOREIGN MINING AND METALLURGY.

It is a matter of some interest to note that locomotives are now produced at Creusot cheaper than in Belgium. Thus some time since a contract for 30 locomotives, with six wheels each, and weighing 30 tons each, to be delivered in seven months, was proposed to some Belgian works at 2520*l.* per engine, delivered free at St. Petersburg. The Belgian firms demanded 2640*l.* per engine, and three months more in which to execute the order; and these conditions were refused. Creusot then came forward, and undertook to deliver the engines within the prescribed period at 2472*l.* per engine, or 48*l.* per engine less than the price originally named by the Russian Government.

It appears that the exports from Belgium of pig and castings, iron rails, and works of iron of every description amounted in 1869 to 280,160 tons, against 189,900 tons in 1868, and 183,460 tons in 1867. Rails play the most important part in these exports, and they were exported from Belgium as follows in the last three years:—

Destination.	1869.	1868.	1867.
Russia ..... Tons	67,419	45,340	67,095
Sweden and Norway	730	—	—
Denmark	475	—	—
Zollverein	9,953	7,299	35
Low Countries	2,666	3,619	3,806
England	2,316	91	206
France	2,058	471	595
Spain	26	130	103
Italy	14,119	3,620	9,033
Switzerland	30	1,143	—
Turkey	28,148	700	—
United States	6,773	6,816	—
Cuba and Porto Rico	60	—	—
Rio de la Plata	220	—	—
Miscellaneous	1,020	1,311	202
Total	136,063	70,559	80,875

Plates were exported from Belgium last year to the extent of 20,839 tons, against 14,412 tons in 1868, and 12,591 tons in 1867. Merchants' iron was also exported from Belgium last year to the extent of 84,208 tons, as compared with 70,616 tons in 1868 and 54,962 in 1867.

The French coal trade shows no material change in the basins of the Nord, the Loire, and the Pas-de-Calais. All the mines are being worked to the utmost possible present extent, and are not yet able to completely execute the orders which they have on hand. Deliveries by railway and by boats are being made as actively as possible, and railway plant is now available in sufficient quantities. The Paris coal market remains in a relatively satisfactory state. The Champagne Committee of Forgemasters held a meeting a few days since at St. Dizier, but the proceedings do not appear to have been very material or important. Among the matters referred to was a proposed railway from Lerouville to Troyes, the construction of which is expected to prove a work of utility to the department. The aspect of affairs in the Champagne district continues favourable. Iron remains in good current demand, with the exception of coke-made, with regard to which it may be observed that the orders received are insufficient to absorb the daily production of the works. Rolled coke-made iron remains quoted at 8*l.* to 8*l.* 4*s.* per ton. Charcoal-made pig is held, but almost nominally, at 4*l.* 14*s.* to 4*l.* 16*s.* per ton; and half-coke mixed pig at 3*l.* 16*s.* to 4*l.* per ton. Machine iron maintains a firm tone in the Champagne group; old contracts are not yet fully executed, but the rolling-mills are receiving already fresh proposals; prices are supported at 9*l.* 4*s.* to 9*l.* 8*s.* per ton, according to the works. The foundries of the Champagne district are stated to have received of late a considerable number of orders for heavy castings. In the Moselle district refining pig continues to be quoted at 2*l.* 16*s.* per ton; the demand continues good, and there is scarcely anywhere any stock. The foundries of the Moselle continue actively employed. Rolled iron is quoted by continuation in the Moselle at 8*l.* 4*s.* per ton. The imports of pig into France in January appear to have compared as follows with those for January, 1869:—

	1870.	1869.
Duty free ..... Tons	10,655	9,927
For shipbuilding	228	6
With payment of duty	265	437
Total	11,148	10,370
As regards iron and plates, the totals stand thus—		
Duty free ..... Tons	5,073	2,564
For shipbuilding	872	900
With payment of duty	165	87
Total	6,110	3,551

The quantities of minerals imported into France in January were as annexed:—Belgium, 9972 tons; the German Association, 8486 tons; Spain, 3940 tons; Italy, 1045 tons; Algeria, 8375 tons; and other countries, 189 tons: total, 32,007 tons.

The Belgian iron trade continues to be pretty well maintained, both as regards orders and prices. The orders relate principally to iron, plates, railway plant, and engines. Some rather important contracts for iron are stated to have been concluded in the Liége basin at a slight advance. The different coal mining districts present extraordinary animation, and the extraction is everywhere insufficient to meet the orders which flow in from all sides. The persistent rigour of the season has stimulated the consumption. Prices have been firmly maintained. A pit is to be sunk in the Horloz concession at Tilleur by means of compressed air. The operation has proved completely successful as regards both the rapidity and economy of the work done.

A company has been formed for the establishment of a great truck manufactory at Revel. At the head of the new enterprise are Baron Ungern-Sternberg and several Berlin capitalists; amongst others M. d'Unruh, President of the Council of Administration of the Prussian Company for the Manufacture of Railway Plant. The capital is proposed to be fixed in the first instance at 800,000 roubles. Some considerable coal-bearings have just been discovered on the borders of the sea of Okhotsk, in Eastern Siberia.

FOREIGN MINES.

ST. JOHN DEL REY (Gold).—The directors have advices to March 1: Morro Velho produce, second division of February, 12 days, 2772 oths.; yield, 1·917 oths. per ton. Gaia produce, second division of February, 12 days, 204 oths.; yield, 1·275 oths. per ton.

DON PEDRO NORTH DEL REY (Gold).—Mr. Symons (March 1) reports—Produce weighed to date, 7231 oths.; estimate for month, 9000 oths. No. 6 has again become disordered and poor; at the date of last advice there was a perceptible improvement, but it did not last; the lode is still defined. We are pushing on the rise, so as to ventilate Alice's west, and prosecute with vigour the working on the promising body of lode at this place. The canoa in the underlie lode continues to yield good general and some box work; the water is interfering with the supply of mineral from this section. The reserves west of gully are yielding a large amount of lode. The horse-engine is working well. Although the ground in Treloar's is not favourable, we are making progress. Three corps are working at the middle adit. A large force is pushing on the work for the new pumping machinery. A small sketch is enclosed, showing the position of the shaft, how deep the auriferous ground has already been found below the footwall of the curve (16 ft.), and at what horizon we shall commence the first cross-cut, to drain about 16 fms. of stoping ground; we hope to sink 2 fathoms per month.

ANGLO-BRAZILIAN (Gold).—Little alteration to note—works prosecuted with vigour. At Haymen's the lode struck is increasing in size. It appears to have been heaved similar to that at Dawson's. The deep adit and Foster's section maintain their promising aspect. Until we communicate to the "fundao" at a deeper horizon from Foster's we cannot give the lodes a fair trial; we are pushing on with a stope to attain th's desirable object. Martin's incline will go to work by the end of the week; the required repairs were heavier than expected.

GENERAL BRAZILIAN (Gold).—Extract from Capt. T. Treloar's letter, Feb. 24: The scale of our operations is greater. At St. Anna the deep adit, shallow adit, and clearing of the old adit are in progress; and at Itabira the shallow adit is progressing rapidly, and middle adit commenced. Explorations also have been commenced. The weather is still very fine, and the operations generally proceeding in a very satisfactory manner. Addition to force appearing daily.

ROSSA GRANDE (Gold).—Extract from Mr. Ernest Hilcke's letter, Feb. 26: The lode at Mina de Serra presents no change of importance since my last; it still maintains its promising appearance, and I am glad to say, by extending the 60 east, we find the size of the lode again improving. The produce for the month I hope will be similar to that of January. In clearing out the adit of the Cachoeira Mine we intersected a large body of lode, of a different nature from that at Mina de Serra; its size has not been ascertained yet; the samp'es taken from it will all show some gold, and judging from these this lode may give from 4 to 5 oths. per ton. Preparations are in hand to give this lode a thorough trial. At the jacotinga exploration at Gongo nothing has occurred to call for particular attention.

SAO VICENTE.—Feb. 26: There is scarcely any change in the levels; the ends being driven are chiefly in clay, sand, and iron, with occasionally small lines of jacotinga. In all operations I am strictly adhering to the instructions given me by Capt. Thomas Treloar, the consulting engineer. Every economy is being used in the working of the mine, and I will do my utmost to promote the interests of the company.

TAQUARIL.—Feb. 26: Within the last week a change of weather has taken place, effecting, I am pleased to state, an amelioration in the sanitary condition of our native force; attendance consequently is improving, and the works generally are progressing with more regularity. Sinking engine-shaft was resumed on 16th inst., and to date our operations have not been materially impeded by water. The rise from cross-cut to old workings holed to surface on 18th; said cross-cut is now being enlarged to facilitate exit of stuff, and upon completion of same we purpose sinking through the crushed matter in old shaft. Timber is coming in plentifully.

SWEETLAND CREEK.—Telegrams from the manager, dated North San Juan, California, state that the Creek's sluice clean up on one month's working amounted to $2000. This is irrespective of the profit on the general working of the mines.

EXCHEQUER.—Captain Chalmers, Silver Mountain, California, March 5: My last report will have informed the directors that the bad ventilation has compelled us to raise a shaft between B and C before drifting further north. I feel satisfied that on reaching the 100, in the winze—it may be the 50—we shall have fine shoots of ore all the way between D and C. During the week just ending we raised 12½ ft. of air-shaft, sunk 13½ ft. of winze, and ran 4 feet of south drift, besides doing a considerable amount of timbering. I send you, by Wells, Fargo, and Co., two large specimens of ore, taken out last week, chips from which assay over $1200 a ton. A picked piece from the south drift, on Friday last, gave as high as—Gold, $283·20 (59*l.*); silver, $1110·69 (231*l.* 8*s.*); total, $1393·89 (290*l.* 8*s.*) per ton. In my last I informed you of 3 tons of ore having been dispatched to Renc, for reduction by the Stetefeldt process; and had it not been for the bad state of the roads, you would already have been in possession of our first shipment of bullion.

CUIABA GOLD MINING COMPANY.—Mr. H. F. Meadows, director of the Cuiaba Gold Mining Company (Limited) sailed from Liverpool, on Saturday, in the Kepler steamer, for Rio de Janeiro, on his way to take possession of the estate and mines of the company at Cuiaba, province of Minas Geraes, Brazil.

PESTARENA UNITED.—The directors have received the following telegram:—"Pallanza, April 4: 580 ozs. of gold obtained during March."

LA MANCHE (Placentia, Newfoundland).—A. B. Cohn, Feb. 17: Our present floors consists of one Blake's breaker; one crusher, 30-in. rolls; ten old-fashioned single brake-jigs; and three strakes, or tyes, capable of dressing about 60 tons per month, at about 35s. per ton. Our vein is of an average width of 3 feet, composed of calcareous spar, embedded in which is the galena. The walls embracing the lode are of a highly indurated porphyritic character, and cut their way down, with slight incline to the south, through metamorphic slate. The ore sold, 200 tons, at Newcastle last July assayed 84 per cent. of lead; silver, 4 ozs. to the ton. Our present workings consist of an adit level, 1500 ft. east from landwash, and five shafts sunk to it; average depth of the shafts from surface to the adit level 100 feet; the yield of ore being to date about 2600 tons. We now want capital to buy an engine, to sink below the adit, all our work being done by water power, which freezes up during our long winters.

PONTGIBAUD.—Capt. W. H. Rickard, April 1: Roure: The 80 metre level, south of Richards' shaft, is in a large lode, composed of quartz, spotted with ore, worth ½ ton per fathom. The 60, south of Agnes' shaft, yields 2 tons of ore per fathom. The eastern cross-cut in this level is still hard. The winze below the 40, a little ahead of the 60 end, yields ½ ton per fathom. The 20 metre level, north on Virginie's lode, yields ¾ ton of ore per fathom. The same level south yields ¼ ton per fathom. The adit, north and south of rise, yields a little saving work. The stollen cross-cut at Paul's shaft has met with nothing worth notice. We have set to cross-cut east to try the ground in that direction. The adit cross-cut, east from the mill, is in stiff sparry ground. Our tribute pitches continue to yield their usual quantity of ore.—La Grange: The 100 metre level, north of No. 1 key's shaft, yields ½ ton of ore per fathom; the lode is hard and sparey. The winze below the 80 is suspended until the 100 end gets under it to

drain it. The 60 north is unproductive. We have set a rise in the 20 north to communicate with the adit level, in hopes of opening tribute ground. Our seven tribute pitches are a little impr oved on the whole, yielding a fair quantity of ore stuff.—Mioche: The adit north is in disordered ground, with scarcely any trace of the lode. The rise in the back of this level yields a little ore that will work at high tribute. The cross-cut east has met with irregular bunches of arsenical pyrites, but no lead ore. At Bouzarat we have met with a small vein in the adit cross-cut west, but nothing of the appearance of a regular lode. We are continuing to drive westward.—La Brousse: The sinking of Basset's shaft goes on regularly, but slowly; it will take yet two months to get to the required depth for commencing the 120 metre level. The 100 metre level north yields a low quality saving work. The same level, south on the main lode, yields ½ ton of ore per fathom. The 100, on the western part of the lode, is improved, and now yields ¾ ton of ore per fathom. The 80, 60, and 20 metre levels south are poor. In the 40 north we have effected a communication with the adit, thereby establishing good ventilation. We have resumed the driving of the level. Our tribute pitches yield fairly.—Pranal: The 70 metre level; south of cross-cut, is poor. The rise in the back of the same level north is in hard sparey ground; the lode yields stones of lead ore and blende. The 50, north of cross-course, is improved, and yields ½ ton per fathom. Our samplings have amounted to 278 tons.

ANGLO-ARGENTINE.—The directors have advices from Capt. J. Vivian, dated Guallian, Feb. 15:—South Mine, Capitano: In driving the cross-cut east at the base of the hill, we have intersected the main lode, and cut into it about 2 feet; it is very compact, and has a splendid appearance. As soon as we have driven through it, so as to know its width and general character, I will write you at once and send you samples of the ore.

[For remainder of Foreign Mines see to-day's Journal.]

THE METALLURGICAL INDUSTRY OF CLEVELAND.*

Throughout the whole history of applied science and the metallurgic arts there is probably nothing which can at all compare with the condition of things now prevailing in Cleveland. In the more limited acceptation of the term, Cleveland is, strictly speaking, but a small portion of the North Riding of Yorkshire,—probably about one-third of it; but, from the fact that the staple industry is the same throughout a large part of Teesdale and South Durham as in Cleveland proper, the term has now popularly acquired a more extended signification. Within a very limited area of the district referred to, the last 20 years have seen an industrial development which has no equal, either in ancient or in modern times, at home or abroad An unusual amount of attention was directed to Cleveland in the autumn of last year, both by the iron and steel trades of the country and by the public at large, owing to the fact that the first provincial meeting of a new scientific association, bearing the name of the Iron and Steel Institute, was then held at Middlesborough, the capital of Cleveland. Owing to the vast amount of interest, both industrial and scientific, associated with Cleveland, it was highly proper that the first provincial meeting of the Institute should be held at Middlesborough. It brought together many persons to whom Cleveland was practically a *terra incognita*, and every facility was freely offered to them for the exploration of the district, so that they might have an opportunity of studying those features which had given to the district a history which, though brief, is perhaps the most eventful and interesting in the whole annals of the iron manufacture.

While the first stage of Middlesborough history commenced in 1829, the connection of the town with the great national industry of iron-making only began in the year 1840-41, when a rolling-mill and other works were erected for the manufacture of malleable iron on a small scale by Mr. Bolckow and the late Mr. John Vaughan. The former is a German, a native of Mecklenburg, and the latter was a man of indomitable perseverance and unflinching industry, whose practical acquaintance with iron-making had been gained while he was a workman at the world-famous iron works of Dowlais, South Wales. At the time just mentioned, and for some four or five years longer, Messrs. Bolckow and Vaughan brought their pig-iron from a distance and transformed it into bars, rails, castings, &c.; but in the year 1845 or 1846 they erected several small blast-furnaces at Witton Park, near Bishop Auckland, where they expected to secure a suitable supply of ironstone to keep their furnaces employed. The supply soon failed, and then they resorted to what was then known as Whitby ironstone, which they obtained on the Yorkshire coast, at Skinningrove, some 10 or 12 miles from Whitby. For a time they continued to work this Skinningrove ironstone, and carry it by ship and by rail, and at considerable expense, all the way to Witton Park to be smelted.

The third period of the history of Middlesborough and Cleveland began about the end of the year 1850, when the town of Middlesborough had a population of not more than 7000 inhabitants. It began with the discovery of the same deposit of ironstone almost as far inland from Skinningrove as Skinningrove is distant from Whitby, and quite within sight of Middlesborough. The difficulties of shipment were so great, owing to the exposed nature of the coast, that it was deemed very desirable to make a careful examination of the geological structure of the Cleveland Hills. It was in the year just mentioned that the search for the mineral proved successful, and the discovery has been the most eventful circumstance in the history of Cleveland. From the circumstance that the mineral was discovered there, it has since been known by the name of the Cleveland ironstone. Claims have been urged on the part of various persons as the discoverers of this famous mineral, as it has already, within the short period of 20 years, been largely concerned in effecting a great revolution in iron metallurgy.

The ironstone thus mined on the sea coast was shipped in large quantities to the iron works on the Tyne and Wear for a number of years before it was discovered inland. It is even stated that some of it was sent to the Tyne as far back as the year 1811. This, however, is certain, that John Vaughan was the first man to recognise the great industrial value of the inland deposits of Cleveland ironstone, and that to his practical knowledge is due not only the tentative introduction of the ironstone in 1850-51, but the present enormous development of the Cleveland iron trade, based, as it is, on the utilisation of those immense deposits of ore. After the employment by Mr. Vaughan of portions of the ironstone deposit of the Cleveland Hills, its enormous extent began to dawn upon the minds of geologists and mining engineers; and since then its distribution, position, and extent have been most carefully determined by Messrs. Marley, Bewick, Cockburn, Allison, and others. It is stating the facts in a very prosaic way to say that the Cleveland ironstone is deposited in such an enormous quantity as to be practically inexhaustible, and that the mining operations are now conducted upon a most gigantic scale. A few details bearing on these points may not be out of place at this stage.

The ironstone of Cleveland is an impure carbonate, but it does not belong to the carboniferous series of strata, as do the blackbands and the argillaceous or clayband ironstones. It occurs in some nine or ten seams, distributed chiefly through the Middle Lias group of the Oolitic series; but they are not all worked, nor, from a commercial point of view, are they all workable. The chief source of the ironstone which is at present being worked is the Main Cleveland Seam, the thickness of which is sometimes from 17½ to 20 feet, as at the Eston Mines. At other mines in varies from this extraordinary thickness down to 15, 11, and even to 7 feet. At the Eston Mines the ore is worked at a depth of nearly 600 feet from the top of the shaft, which opens out on a bleak and uninhabited Yorkshire moor. Sometimes the main seam is split up into two seams by shale and other beds, the upper being distinguished palæontologically as the *pecten* seam, and the lower as the *avicular* seam. Where the main seam is undivided it is generally richer in metallic iron than where it is split into two seams; in the former case the ore may yield from 30 to 31 per cent. of metal, while in the latter the yield is frequently from 28 to 26 per cent. of metallic iron. Cleveland ironstone is highly fossiliferous—indeed, it may be said to be quite charged with animal remains, and consequently there always occurs in the iron extracted from it a notable quantity of phosphorus, the presence of which has hitherto rendered the production of steel from it, without puddling, a scientific impossibility. Analyses of Cleveland pig-iron give not unfrequently from 1·2 to 1·3 per cent. of this troublesome element; and yet, although it is generally regarded as an undesirable ingredient of manufactured iron, it would almost seem that Cleveland iron, in the form of railway bars, has a greater degree of durability than iron which is practically free from phosphorus. Besides the seam referred to—the Main Cleveland Seam—there is another workable seam, known as the Top Bed. Geologically, it is from 230 to 250 feet higher up, resting on the top of the Upper Lias, the chief feature of which is the well-known Whitby alum shale. This Top Bed is only worked at three places—Glaisdale, Rosedale, and Port Mulgrave, on the coast. At Rosedale there is also a peculiarly deposited bed of rich magnetic ironstone, occupying the same geological position as the Top Bed just spoken of. It sometimes yields as much as 49 per cent. of metallic iron.

At first the Cleveland ironstone was generally quarried where it cropped out on the surface, but the plan now adopted is to sink shafts from the surface or drive levels from the hill-side, or both, and then work the mineral upon the "bord and pillar" principle. Some of the iron-smelting firms have mines of their own, others contract for their supply of mineral. As the mining operations of Cleveland are conducted upon such a gigantic scale, it is but natural to expect that no antiquated measures are adopted unless their utility has been fully demonstrated. To be "time-honoured" is not alone sufficient; they must be the most economical methods of procedure, both as regards the mineral to be worked and the labour and life spent upon it. One finds in use the most highly approved mechanical appliances, both for "winning" the mineral and for draining and ventilating the mines. As a single illustration it may be mentioned that in one of the mines explored by the present writer—one belonging to Messrs. Bolckow, Vaughan, and Co. (Limited), at Eston—the engine-plane was brilliantly illuminated throughout nearly a mile and a half with coal gas. The same plane is a level or drift which serves as an air-course inwards and a water-course outwards. The water is drained from the mine at the rate of about 600 gallons per minute, and is carried by gravitation to the company's blast-furnaces, where it takes the place of water, which formerly cost 1000*l.* per annum. The ironstone, which is the raw material forming the prime requisite of the great industry of Cleveland, is obtained so cheaply that it can be laid down at the furnaces at a cost of 4*s.* to 4*s.* 6*d.* per ton; and as it contains very frequently from 28 to 31 per cent. of metallic iron, the ore for a ton of pig-iron costs less than 14*s.* It is in a very great measure owing to the extraordinary abundance and cheapness of the raw ironstone that the Cleveland ironmasters have, in a comparatively short term of years, acquired for their district the proud distinction of being the greatest seat of the iron manufacture in the whole world. It was in the month of September, 1850, that the first sample of Cleveland ironstone from the Eston Hill was smelted at the Witton Park Iron Works; but it was only a few months afterwards that active measures were taken for the practical treatment of the mineral at Middlesborough, within easy reach of the ironstone deposit. Messrs. Bolckow and Vaughan were the first firm of ironmasters to enter upon the Cleveland industry.

In the Cleveland district the ironstone is in some instances calcined before leaving the mines, but in most cases it is calcined in very close proximity to the blast-furnaces where it is to be smelted. The operation is effected in calcining kilns, never in open heaps or "bings," such as may be seen in various iron districts. These kilns have no very distant resemblance to lime kilns. They are generally of very considerable size, sometimes 50 ft. in height, and upwards of 20 ft. in width; indeed, they are frequently a good deal larger than many of the blast-furnaces of South Staffordshire, South Wales, and Lanarkshire. The raw ironstone is raised to the top of the stacks of calcining kilns, either by inclined planes, up which the laden wagons are dragged, or by hoists of great ingenuity. As a rule, it is thoroughly roasted or calcined by means of 1 ton of small coal or "breeze" to from 30 to 40 tons of green ironstone. In every direction labour-saving appliances are to be found. Even in the discharging of kilns an ingenious hopper arrangement has been applied, which economises labour to a remarkable extent. The roasted stone is charged into great iron barrows without any shovelling being required, and by means of them it is lifted in the furnace-hoists to the top of the furnace, and charged into them quite hot. This plan of charging the furnaces with calcined ore while it is dry and quite hot also effects some economy in the fuel.

The blast-furnaces of Cleveland form quite an extraordinary feature throughout the whole district, whether we regard their number or their size, or the mode of working them. In no other iron-making district can such a sight be seen as that which meets the eye of the visitor to Middlesborough and the district immediately surrounding it. At the present time (February, 1870) there are no fewer than 122 blast-furnaces in the Cleveland district, if under that term it may be permitted to include Durham, considering that Cleveland ironstone is almost universally used in the blast-furnaces of that county. True, there are 12 of that number of furnaces that are not likely ever to be again brought into use in their present form, as they are too antiquated, and not in accordance with the prevailing notions as to what a blast-furnace should be. Then there other nine which are out of use, but as they are available they may again be called into requisition. There are thus left 101 furnaces, all of which are in blast; but besides these there are 14 new ones being built, one being raised, and other two being re-built or modernised. Somewhere about 70, or two-thirds of the whole, are clustered within an area so limited that a radius of three or four miles from the centre of Middlesborough would include almost every one of then. And then, such furnaces as they are in point of size, almost universally! Throughout Monmouthshire and South Wales there are probably not fewer than 200 blast-furnaces, while out of that great number only four or five reach to a greater height than 50 feet. Many of them are only 35 to 40 feet high, and there is even one that rises no higher than 25 feet. In South Staffordshire from 45 to 50 feet is the commonest height for the blast-furnaces, and in Scotland the greater of those two elevations is but seldom exceeded. But what a mighty difference is observable throughout Cleveland. Such a puny thing as a furnace only 45 feet high is exceedingly rare, and in comparison with many of the other colossal structures it might almost be spoken of simply as a crucible, or a tiny smelting-pot. Heights of from 70 to 95 feet are common throughout the whole district, while at Ferryhill there is one furnace that towers up to the extraordinary height of 103 feet, and is, therefore, doubtless the most gigantic iron smelting-furnace in the world. In the short space of 20 years Cleveland blast-furnace practice has passed through several phases. At first the furnaces were built only 45 feet high, then the height was increased to 56 feet, next to 60 feet, and then (in 1863) to 75 feet and soon afterwards still greater heights were adopted. Some of them had but very short lives, comparatively; they were erected and in use but a few years when it was resolved to raze them to the ground, and rebuild them of much larger dimensions. Amongst the new furnaces now in course of erection it is stated that there are two which are to be built to the height of 90 feet; and even the great furnace at Ferryhill is to be overtopped by one which is to reach a height of 120 feet! And as is the height of the Cleveland furnaces, so is their internal diameter at the widest part, or what is technically known as the "boshes." It generally varies from 16 to 25 feet, but in the case of the Ferryhill furnace it is 27 feet. The two 90-feet furnaces just referred to are to be 30 feet wide at the boshes, or one-third of the height; and it is proposed to make the 120-feet furnace no less than 33 feet wide at the boshes. Were the Vulcans and Tubal Cains of antiquity to revisit the earth, they would doubtless stare on coming within sight of these immense smelting crucibles. The internal capacity of some of the Cleveland furnaces amounts to 25,000 or 26,000 cubic feet—that of the Ferryhill furnace being 33,000 feet; and the weekly production of pig-iron from a number of the furnaces—fourteen castings, or two daily—is from 420 to 450 tons; at Norton it is as much as 550 tons, A single casting from one of the Ormesby furnaces has been known to weigh 45 tons. With furnaces which, together with their great number, have such a prodigious yielding power, it is scarcely to be wondered at that the Cleveland ironmasters are now making nearly one-third of all the pig-iron produced in Great Britain. One of them is the greatest individual maker of pig-iron in the world—Mr. T. Vaughan, of Clay Lane and South Bank Iron Works. His annual make is nearly 250,000 tons.

For a considerable length of time a vigorous and interesting discussion has been going on amongst the Cleveland ironmasters with reference to the maximum dimensions that may be allowed in the blast-furnaces consistent with a due regard to the highest degree of scientific economy in the working of the same. Mr. Isaac Lowthian Bell, who may, perhaps, be justly regarded as the greatest authority in the science and practice of iron-making amongst practical ironmasters, has taken his stand after having instituted probably the most elaborate series of experiments in blast-furnace practice ever made. The paper which he read at the Middlesborough meeting of the Iron and Steel Institute, "On the Development of Heat, and its Appropriation in Blast-Furnaces of different Dimensions," treats the subject very exhaustively. Mr. Bell obtained his data for calculations from furnaces of almost all capacities, ranging between 3500 and 33,000 cubic feet, and his verdict was that the most economical furnaces would ultimately prove to be those having capacities ranging from 12,000 to 25,000 or 26,000 cubic feet. There are, however, many ironmasters and blast-furnace managers who do not agree with the dictum pronounced by Mr. Bell, and there is a great deal to be said in favour of the assumption that the maximum limits have not yet been reached. In the opinion of Mr. C. W. Siemens, F.R.S., great results must be looked for rather by increase in the temperature of the blast than by simply increasing the capacity or height of the furnace. As a rule, every increase hitherto made in the heights of blast-furnaces has been attended with a saving of fuel, not in Cleveland only but in other iron districts also. For instance, by raising the height of some of the cold-blast furnaces at the Lilleshall Iron Works, Shropshire, from 50 to 70 feet, there was a saving of 7 to 8 cwts. of coal per ton of iron made. In the Cleveland iron-smelter's vocabularly the term "waste gases" is unknown. According to Mr. Bell, the system now in operation in Cleveland effects a saving of something like 600,000 tons of coal per annum in those works smelting the ironstone of North Yorkshire. Such scientific economy cannot fail to have important social and political considerations. The mode of closing the furnaces is generally the same in principle throughout the whole district; it is the well-known hopper-and-cone arrangement; and the gases are drawn off very near the top of the furnace, and conducted away by means of capacious tubes to be used in generating steam and in heating the air of the blast. Theoretically, there should be no coal used in either of these operations; they should both be accomplished by means of the furnace gases, and in practice this state of perfection is fully reached at some of the works. As coke is the fuel used in Cleveland, the combustible gas which is generated consists almost entirely of carbonic oxide, and it is the calorific powers of this gas which the iron-smelter has to utilise. Of course, there is also the atmospheric nitrogen of the air of the blast passing through the furnace. Of necessity, it absorbs a vast amount of heat, but of this heat it is well deprived before it is thrown back into the atmosphere. Since the hopper-and-cone arrangement of closing the furnace-top was generally adopted throughout Cleveland it has been very materially improved, especially by Mr. Charles Cochrane, of the Ormesby Iron Works, Middlesborough. His improved arrangement is that of a double-closed furnace-top, and has for its object the diminution of the amount of gas escaping from the furnace at the time of charging. It has done this so effectually that for one furnace the saving in fuel alone is equal to about 164*l.* per annum, while the necessary apparatus only costs 200*l.* In the hands of the Cleveland ironmasters the great invention which was given to the world by James Beaumont Neilson—the hot-blast—has of late almost revolutionised even Cleveland iron-smelting. Neilson seemed to think that he had arrived at the acme of perfection when he got the temperature of the blast raised to about 600° Fahr.; and in Scotland, where the invention had its birth, the blast is rarely heated much beyond that temperature. But in Cleveland, where no such deference is paid to old customs and traditions as they receive in Scotland and in South Staffordshire, there seems to be no resting place. Improvement succeeds improvement with extraordinary rapidity, and at present it is in the direction of increased temperature in the blast rather than in increase of furnace capacity that further economy is to be sought for. It is no uncommon thing in Cleveland to find the blast heated to from 850° to 1000° Fahr., but even the greater of those temperatures is not deemed sufficient. Under the leadership of Mr. Cochrane the tendency is still upwards. That gentleman has applied at the Ormesby Works the Siemens' regenerative system, as adapted by Mr. E. A. Cowper, C.E., F.R.S., for the heating of the air of the blast. He has of late used the blast at the unprecedented temperature of 1452° Fahr., and the result of his experience is that for each 100° the blast is raised there is a saving of 1·34 cwts. of coke per ton of iron made. It is the opinion of Mr. Bell that 20 cwts. of coke per ton of pig-iron is about the lowest minimum that can be attained; but Mr. Cochrame is sanguine that a minimum of 13 cwts. can be reached, provided that the blast is heated up to 2000°, and he has determined to aim at reaching that minimum consumption of coke, unless experience should prove it to be impossible to attain it. Even a consumption of only 21 cwts. of coke per ton of pig-iron must be deemed very marvellous, when it is remembered that twice that amount is employed in producing a ton of iron in cold-blast furnaces. There are instances of furnaces in the Cleveland district—Consett and Ferryhill—working on the consumption of 17 or 18 cwts. of coke per ton of pig-iron, but they are somewhat exceptional, as the ironstone used was either the rich Rosedale stone or not exclusively Cleveland stone, but a mixture of it with hematite, and, therefore, containing at first a much larger proportion of metallic iron than is customary throughout the district. Superheated air is also in use at Consett Iron Works, the temperature of the blast being about 1400° Fahr., and produced in a hot-blast stove, which is a modification and simplification of the Siemens-Cowper stove in use at the Ormesby Works. Report speaks very favourably of it as a fuel-saving appliance. The inventor of it is Mr. Thomas Whitwell, of the Thornaby Iron Works, Stockton.

From the facts already alluded to, and on account of the interesting scientific and practical problems which are at present being worked out, the eyes of all iron-making districts are anxiously directed to Cleveland. It is iron-smelting which really forms the staple industry of that district, and, although it is scarcely 20 years since it had its very small beginning, it is already of such enormous proportions that every other district is completely overshadowed by it. But although iron-smelting is *the* staple industry of Cleveland, it is not the only one. The manufacture of malleable iron is carried on to an immense extent throughout the district with great skill and energy, and it has called into requisition some 1400 or 1500 puddling-furnaces, possibly even more: and some of those furnaces are amongst the most economically effective appliances known to the metallurgist. In some of these the consumption of coal per ton of puddled bar has been reduced from 25 to 15 cwts. It was in Cleveland, likewise, that works were first erected by Messrs. B. Samuelson and Co. for the practical application of the Siemens-Martin process of manufacturing steel; and the experiments made by that firm at the Newport Works would seem to indicate that there is a great degree of probability that steel ingots for rails may yet be made at a price little exceeding that of puddled bar. This is not the place to enlarge upon the fact, but it may be stated that in the Cleveland iron trade two great social problems have been solved—the prevention of strikes and lock-outs, by the establishment of a Board of Arbitration and Conciliation; and the possibility of the co-operative system being carried out in a large iron-making establishment, the employees participating with the capitalists in the division of the net profits of the business. This system has been in operation during three years at the works of Messrs. Fox, Head, and Co., and it has just been resolved to continue the arrangement for the next five years. Great scientific and industrial results have been accomplished by Cleveland already, but it is not to much to expect that she has in store other equally great, if not greater, triumphs for the historian to record. The production of rails in Cleveland is at the present time not far short of 750,000 tons, and probably three-fourths of all the iron-plates used in shipbuilding are made from Cleveland iron. The readers of this Journal will recollect that brine-springs have been found under the town of Middlesborough; and there is every likelihood of the manufacture of salt being added before long to the other industries of Cleveland.

* Abstract of paper published in the "Quarterly Journal of Science" for April.

THE INSTITUTION OF CIVIL ENGINEERS.—At the meeting of members, on Tuesday, Mr. Charles B. Vignoles, F.R.S., President, in the chair, 19 candidates were balloted for and duly elected, including four *Members*—Mr. John Bailey, Dublin; Mr. William Elsdon, Melbourne, Victoria; Mr. Alexander Kendall Mackinnon, director general of public works, Monte Video; and Mr. Thos. Fothergill McNay, Westminster. Fifteen gentlemen were elected *Associates*—Mr. John Anstie, B.A., Westminster; Mr. John Collins Boys, Granville-place; Mr. Thomas Cargill, Beaufort-buildings; Mr. James Robert France, late acting engineer to the Submarine Telegraph Company; Mr. H. Gaerth, Westbourne-park-terrace; Lieut. George Edward Grover, R.E., Woolwich; Mr. David Gravell, student Inst. C.E., contractor's staff of the Suczawa, Jassy, Roman, Bottaschany Railways in Moldavia; Mr. Frank James, Princess-street, Commercial-road; Mr. Joseph Kincaid, B.A., St. James's-street; Mr. Henry Ernest Milner,

late engineering staff, Windsor and Annopolis Railway; Mr. Thos. Newbigging, manager of the Rossendale Union Gas Works, Bacup; Mr. Ernest Bengough Ricketts, engineer's office, Trinity House; Mr. Frederick Warburton Stent, Westminster; Mr. Edward John Tatam, Moulton, near Spalding; and Mr. Clarence Edward Trotter, student Inst. C.E., Westminster. The following candidates have been admitted *Students* of the Institution:—James Hall Blake, Massey Bromley, B.A., John Henry Eykyn, Alfred Fyson, James Gilchrist, James Henry Greaves, Hilin William O'Neale Neale, William Patten, Robert Pickwell, and Charles Graham Smith.

The Royal School of Mines, Jermyn Street.

MR. WARINGTON SMYTH'S LECTURES.

[FROM NOTES BY OUR OWN REPORTER.]

LECTURE XXXIV.—We have now (said Mr. SMYTH) devoted some attention to the shafts and their security, and we naturally consider next the means by which they are traversed by the men in going to and leaving their work. In the early stages of mining, or when the depths penetrated are inconsiderable, these do not constitute a matter of much importance, but as the shafts become deeper, and the works below more extensive, so that the labour of large numbers of men is required, the mode of descending and ascending becomes highly important, both as regards the safety of the men and the economy with which it is carried out. When we look at the mining districts of Europe at large, we find that the depths are constantly increasing from which the mineral has to be raised, and to which the men have to descend, and, therefore, that is a matter which has to be considered with much greater care than formerly. It is only 30 years ago since it was considered an extraordinary thing that a coal mine shaft at Monkwearmouth should be sunk to a depth of 300 fathoms, or 600 yards; and it remained the wonder of the day for 15 years; and then that depth was exceeded by the famous pit at Dukinfield, in Cheshire, which went down to 700 yards. Now, however, that has lately been exceeded by a pit at Rosenfield, near Wigan, which is 800 yards, so that in this country we have advanced greatly. If we look at foreign countries we shall see a similar state of things. In Belgium, for instance, the pits used to be no more than from 300 to 500 metres; then they advanced to 600 and 700, and in one case recently a depth of 1000 metres has been reached. In metalliferous mines great depths have been reached, and in the district of Przibram, in Bohemia, they have attained a depth of 300 fms., and in some cases considerably over that. In the Hartz, again, the Samson Mine, near Andreasberg, is worked at a depth of 400 fathoms.

The greater difficulties which result from the increased depths of our mines are sought to be met by improved machinery, and by its extended application; before considering which we will look a little at the less artistic contrivances of earlier days. Whatever occurs in the actual working of shallow mines will frequently occur on a small scale in parts of large mines, whilst the principal shafts are ascended and descended by the more elaborate arrangements of modern times. There is, however, a great difference between collieries and metalliferous mines in this respect. The shaft of a colliery, as you have seen, is invariably sunk vertically, to meet the band or seam to be worked, and machinery is put up to raise the material and the men through that shaft alone, there being no subsidiary workings of the same kind, except, perhaps, some openings in the workings themselves, fitted with ladder-ways for the men to get through. But in metalliferous mines the latter are not exceptionable, but are going on constantly. You will see by the longitudinal section of a large metalliferous mine [exhibited] that there are a great many communications from one level to another, above or below, called "winzes." Through these the material has to be raised to the level most convenient, and, besides, there is the work going on through the principal shafts. Now, the winzes require some sort of mechanical arrangement by which the mineral or the men can be raised through them, and which are usually of the same character as those used in the earlier stages of the mine. In the old book of Agricola there are portrayed all the various methods in use in his time for descending underground. First of all we may take ladders, which even now are much used in some districts, and with advantage, when well constructed, and placed at a convenient angle of inclination. Next we have a representation of men being lowered by a windlass, seated on a small cross stick. In another plate the excavation is slanting, at an angle of 30 to 40°, and the men slipping down on a sort of sled, with a rope to lay hold of to steady them in their descent; and then, lastly, we have a series of steps cut roughly in the rock, which not only answers the purpose of sending the men down, but enables the horses to be taken down into the mine also. Steps of this kind are employed to this day in some of the great lead mines of the North, where circumstances have allowed them to put down a winding staircase, and in some of the districts of mountain limestone a similar arrangement is carried out. Other cases may be quoted in the collieries of Flintshire; and no one can help admiring the extremely convenient arrangements, almost amounting to luxury, at the salt mine of Wieliczka, near Cracow, where steps not less than 6 feet wide are constructed, forming a staircase which descends at a very convenient angle of inclination; and down in the mine itself they have steps cut into the solid rock-salt, looking something like marble steps. I should here mention another case of great comfort and security, that of the admirable arrangement of the descent at the mine of Monte Catini, in Tuscany, which I have mentioned before, where the entrance of the men is provided for by having steps cut at convenient angles, winding down to the levels, and at any place where there is a chance of a break down the roofs are all carefully lined with arched masonry. These are comparatively exceptionable mines, which are expected to last a long time, and in which no expenses are spared for the comfort and security of the men, that being, in the long run, the best economy. I do not say anything about raising the men with a rope, as in the first stages rough and ready expedients of this kind are not dangerous, and save time, and thus the men mostly go down astride of a stick, or in the kibble by which the mineral is raised. In sinking winzes the same thing is usually done, and away from the main shaft, the convenience of these methods must depend on collateral circumstances, such as the strength of the ground, and the inclination of the seam or lode. Where there is a considerable inclination the men are half pulled up and half walk up, and many modifications of these plans are in use. In some of the Spanish mines, from an undue regard to economy, and to save the wages of the windlass men, the greater part of the miners are lowered, sometimes with one foot in the kibble and the other out, sometimes with one foot in a stirrup-iron, or loop, attached to the rope, holding on higher up—a most dangerous practice. A law has, however, been passed to the effect that no one shall be lowered unless secured by a strap round the body, so that if the miner lost his balance he would still be kept in an upright position. When the depth becomes as much as 20 fathoms methods of this sort are thrown out of use; and a practice has arisen for the men to go up at the point where the mineral is raised, and where, consequently, the machinery can be used for lowering or raising them. If we consider the enormous amount of manual labour required to raise the quantities now commonly brought up in a day from a depth of 300 to 400 yards, we shall see that it would be out of the question to trust to that kind of labour, and that machinery is indispensable; and the machinery being there, it is obviously better for the men to be lowered and raised by its power. Ladders, however, are the usual means of descent where machinery is not employed. These vary a good deal. In the smaller lead mines of the North of England and in Derbyshire they have very rude methods of descent. In many cases the ladders are simply pieces of wood projecting from the sides of the shaft, driven in between the stones of the walling. A great inconvenience attends this plan, as there is often a strong draught, which may extinguish the light carried by the person descending, and then if two or three of these pegs be worn or knocked away in succession he is exposed to great peril. The next step to this is putting in stemples, which are placed across at 4 feet asunder, sometimes parallel and sometimes transversely. In the winze, were it is not more than 2 or 3 fathoms deep, these are very suitable, and thus, instead of by regular ladders, the men climb up and down by the help of a rope. When, as in Yorkshire, the stemples are placed where the depth is from 40 to 50 fathoms, it is very hard work, and they are so large for the hands that those accustomed to a good ladder will not approve of them. The simplest kind of ladders proper are those in use in America, Hungary, and in some parts of the North of Europe, and they are a kind which are most advantageously employed when blasting is going on, and when, consequently, smaller ladders would be knocked to pieces. They are formed of a strong beam of wood, in which the steps are cut at proper distances. Another sort is very often used (although it is not to be recommended where there are a great number of men), in which strips of wood are nailed across an upright, like a poultry ladder, and placed against the sides of shafts for a considerable height. Wherever it is used means ought to be adopted for fixing the cross bars securely. The staves of the ladders in Saxony are usually flat, and are put through holes in the side pieces. In England they are usually round, and made of ash; with, in Cornwall, at the distance of every ten or eleven a strong wrought-iron stave, which holds the ladder firmly together. As a rule, iron staves are not advisable, and in winzes and places not often travelled through they will sometimes be found to have utterly perished, so far as strength is concerned, nothing being left but a mere crust. The distance at which the staves are placed asunder is a question which greatly affects the comfort of the men. If they were as close as those of a bricklayer's ladder no one would like them. It is usual in mines to have them from 10 to 12 in. apart; 12 in., however, are found to be a great pull upon ordinary legs, and 10 in., on the other hand, is too short a distance; 11 in., therefore, will be found as a rule to answer best, and that rule is generally adopted in Cornwall. Ladders are sometimes made of chain, for the purpose of being used in winzes, and are so far convenient that they can be raised from places where they are but seldom wanted, and removed elsewhere. It has been proposed in Belgium to substitute for ladders wrought-iron staircases, of a spiral form, winding round a perpendicular centre; and that plan might be useful when any accident happens to the machinery by which the men are raised and lowered. Thus cases occasionally occur in which the men, 100 or 200 in number, are left at the bottom for a whole night, or longer, because an accident has happened to the machinery, who might have ascended had there been a ladder-way.

Although it is to be hoped that ladders will some day be almost entirely superseded in regular work, and only retained for these exceptional cases, they are yet so numerous and general that it is a question of great importance to the mining engineer to consider how he may best place them. If we have an inclined shaft 250 fms., it is convenient to put the ladder along the footwall of the lode, but not close to it, so that any rubbish falling may pass through. In vertical shafts the ladder must be placed at an angle which is easy to climb, although a great deal will depend upon the size of the shaft. This is a subject which requires great care. At this moment a great number of our mines have the ladders placed so badly that where there are considerable distances to climb the health of the men is most seriously injured. It must always be remembered that these things are better done properly at first, as it would cost a great deal of money and time to take out a set of ladders and replace them with better. The worst ladders are those which rest upright against the wall of the shaft, of which there are not now so many cases as there used to be. A daily ascent and descent of 50, 60, or perhaps 80 fms. upon a perpendicular ladder is found to affect the heart and lungs very powerfully and injuriously, besides the danger of instant death by missing hand or foot hold. In such a case, the centre of gravity being outside the ladder, the unfortunate miner falls clear, and is dashed to pieces; whereas if the angle of inclination is sufficient he falls upon the lower part of the ladder, and has at least the chance of grasping some of the rounds. It is now, therefore, considered necessary to give an angle of inclination (say) of 75°, which a man in good health may use without great exertion, and without prejudicial effect upon the heart and lungs of any kind, besides which such ladders are much less dangerous. The question, then, is how to get that angle where the shaft is perpendicular. This is done by a system of sollars, or platforms, by which the descent is divided. Each of these sollars has a man-hole, with a trap-door, so that in case of an accident a man would not have a fall which must necessarily be fatal. In the Hartz and in Norway, where everything is done that is possible to be done for the health and safety of the workmen, very short ladders are used, the length being not more than 2 fms., and each sollar is well guarded with sides. In Saxony and Cornwall lengths of 4, 5, and 6 fms. are common. In the ordinary run of English mines from 20 to 40 fms. are the lengths which prevail. These long lengths, however, are all more or less painful and fatiguing, and in the deeper mines the average life of miners is shortened in consequence of this nearly as much as by the vitiated air they breathe, and other reasons, so that many plans are proposed to get rid of this labour. A great point in the problem is the consideration that the men are working at various depths on different levels, some at the bottom, and others, it may be, half-way up to the surface, so that while some have long others have short distances to climb.

For some years past, and in the last 30 years especially, this fact also attracted attention—that a vast deal of labour is expended in the mines by the men which might be saved, and their physical powers not worn out before their time. Thus, if we suppose the case of a shaft 1000 ft. deep, that 500 men are employed below, and that the average weight of the men is 120 lbs., each man will have to raise his own weight, and thus lift $500 \times 120 \times 1000 = 60{,}000{,}000$ lbs. 1 foot high. It is reckoned that 1,000,000 of foot pounds is a good, or rather a hard, day's work for a man, and thus 60,000,000 lbs. represents 60 days' labour. If the value of that be put only at 3s. there will be 9*l.* wasted every working day by the men having to climb from the bottom to the top, to say nothing of their going down. Reckoning 300 working days, the loss per annum is 2700*l.*; and if that be taken at 4 per cent. it will represent a capital of 60,000*l.*, which, if put into machinery, would bring the men to the surface in ease and comfort, and save them from diseases of the heart and lungs, from which they are grievous sufferers. About 1830, considerations of this kind began to produce practical results both in the Hartz and in Cornwall, and a satisfactory apparatus was hit upon almost simultaneously by Mr. Oppenheim in the former, and Mr. Lewis in the latter, and called "fahrkunst." In Germany and "man-engine" in Cornwall. It was first used at the Samson Mine, in the Hartz, and its advantages were so obvious that it was soon applied to other mines. In Cornwall it was first adopted at the Tresavean Mine, and it is used in many mines, but it has made far greater way on the Continent than with us. This machine when first erected was a little more complicated than it is at present. The idea suggested itself in this way. The ladders were placed between the pump-rod, and in ascending the ladders one day, Mr. Lewis thought how great a thing it would be if a lift could be attached, and he could ride up the length of the stroke of the rod, and then up the next, and so on to the top. A piece of paper was nailed to the wooden rods, and it was at once seen to be the right principle. A model was made, and then it was applied to actual circumstances. Steps were attached to two pump-rods, and the man going up would step at the end of its stroke from the one to the other, and so by a succession of lifts be taken from the bottom to the top as quickly as the number of strokes per minute done by the pumps. The same action reversed brought the men down. This was the principle of the double man-engine and of the fahrkunst. At first few men only would travel in this way, for the shaft being open and unprotected it required a good deal of nerve to step across the yawning chasm beneath.

Sollars and hand-rails at the places of change were then brought into use, and eventually the whole of the ascent and descent was effected in this way, with rapidity and safety. Subsequently the man-engine was constructed, with a single rod; and the up and down platforms on which the men ride being made at the end of each stroke almost to touch, the step from the one to the other is made without danger. In some places the engine is enclosed, so that if anyone did fall it would only be from one sollar to the other, or the length of the stroke. These in England are about 2 fathoms apart, and as the engine makes 8 strokes in a minute the rate of ascent or descent is 72 ft. in a minute. This is an immense boon to the men, and where their numbers are considerable a great advantage to their employers. The cost of the single man-engine is not large—something like from 1500*l.* to 2000*l.* for a depth of 250 fms.; and its use, therefore, it could almost be wished, should be made compulsory in all shafts of 100 fathoms or more in depth. It may be as well to mention that visitors and novices should be cautioned before travelling with these machines, as two or three lamentable accidents have occurred for want of presence of mind. It is some time before anyone not accustomed to the strange noises in a shaft, and those created by underground operations, feels sufficiently cool and collected to change his position at the right time. There might be danger, too, when going down in meeting a stream of men ascending; but when proper discipline is maintained, and the rules understood, one steps aside, and the journey for both is completed with security. The comfort and ease of the system, however, are so great that I have never heard of a single instance in which men still prefer to travel on the ladders to being lifted in this convenient manner.

LECTURE XXXV.—With regard to the different modes now in use of travelling through the shafts, it is much to be wished (said Mr. SMYTH) that we had some better statistics than any now available. It is of use to know the relative degrees in which one mode or the other have been adopted, and the efficiency and freedom from accidents of each. There can, however, be no question that in former days the mode of travelling by means of a rope when the shaft was unguarded was most dangerous, and that the number of accidents would tell unfavourably on that system as compared with ladders. Indeed, if a suitable mode of placing ladders be adopted, and precautions taken such as those described in the last lecture, there is no doubt but that it is one of the safest means by which the men can go their work and return from it, but then the wear and tear is great and exhaustive, and there is much want of economy. There are, then, a variety of reasons why there should be a thorough investigation into the subject, and why it is so much a matter of regret that we have not better statistics with a view of settling the relative advantages of different methods. When the mines are deep we have already seen the great advantage to be gained by applying the machinery already erected to the working of the fahrkunst, or man-engine; but it has been sometimes urged that as each man has to be taken singly there must be great delay, but there are really no grounds for this criticism. Every step of the machine is capable of taking a fresh man, and the whole may be passed through in a very short time; indeed, the length of each stroke represents a man, and the number of strokes per minute so many men per minute, and the calculation, therefore, is easily made for the whole complement; and then the machine-power is applicable all the rest of the day for other purposes. It is practically found that the time the engine is occupied is less than with the rope. Supposing there are 400 men employed in a colliery where the rope is used, it is doubtful if more than four men, and certainly not more than eight, would be allowed to ride at once. If we take eight, the kibble, or whatever it may be, will have to make 50 journeys in taking the men to work. Suppose each takes two minutes, and half a minute each in getting in and out, that makes 150 minutes, or two and a-half hours during which the machinery is thus occupied. Double that for raising the workpeople, and it is five hours per diem actually employed; and in many cases, when the sets do not go down regularly, the machinery cannot be employed in any other work. I am speaking of what is called slow time, but if the three minutes be abbreviated other dangers to some extent are introduced. Now-a-days in a colliery of moderate depth three-quarters of a minute instead of two minutes is occupied in the descent, and the speed is even greater in some. We have, however, no statistics as to the comparative risks of fast and slow winding, and either or both in comparison with the fahrkunst, or with ladders. The whole subject is one of growing importance: but it is a significant fact that the travelling-rods on the Continent have increased in number. The continental machines are more or less dissimilar to those employed in Cornwall. In some of the Prussian districts angular-iron has been employed in lengths of 20 ft. instead of wooden rods. These placed two and two make a combined rod, which, on the whole, is less heavy than wood, and has the advantage that the weight can be apportioned to the distance. Thus at a pit in the Ruhr district of Westphalia the upper rods weighed 176 lbs., the middle 170 lbs., and the lower 130 lbs. This is only one case quoted out of a number of collieries of moderate depth in which it is thought desirable to employ means of this kind to bring the men up. In the South Belgian coal field, at Mariémont, the men are carried with a great degree of rapidity and security by a machine constructed by M. Waroqué, upon what the French call the échelon movement. The shaft, which is 300 yards deep, is placed in the centre of a number of collieries, the men from which have access to it. It is fitted so completely that it is impossible for any accident to occur while the engine is working, and 700 people are lowered and raised per day. The shaft is elleptical, and the steps are so large (and have a rail round them) that two men may travel on each step. With respect to Cornish arrangements of this sort, they have the advantage of having the steps more nearly together, and so safety is secured. Another plan in use at Mansfeldt, in Prussian-Germany, said to work well, has the steps fixed at the four corners, and the men step off and on to platforms.

We will now turn to the subject of working away the main portion of a deposit, which is called the "working of mineral," in contradistinction to "winning," or laying it open, and for which the French have the term "exploitation," and by which they mean its removal on a large scale, when it has been prepared by other arrangements for that purpose. I have already shown you under what varying circumstances the repositories of useful mineral occur; how different is the character of roof and floor in different localities; the questions which are governed by the thickness, and whether the whole substance is or is not to be removed; and according to all these the nature of the work now to be considered will be varied. We will, however, confine ourselves to-day to metalliferous mines, and lodes of moderate size. We have now a portion of the work to do in which the general management comes into play to a greater extent than we have hitherto considered. The levels and shafts being completed, much depends upon the manner in which certain important considerations are kept in view, and certain indispensable rules or plans adhered to. It will be convenient to group these plans into several heads:—

1.—The workings must be so arranged as to keep them clear of water. This would seem an obvious and universal duty, but you will find very frequently in mines on a small scale that it is lamentably neglected. Thus, when they find the ore is going down the men are apt to remove that which looks the best, without reference to the future, and to cut it away in stopes, trusting to remove the water by manual labour; but the difficulty of raising the ore and the water increases with every foot they go down. The shaft may be only a windlass shaft, and if it has to be sunk lower the men will have to work in the water. The consequences are so well known, that getting ore in this way is termed "dragging it out by the hair of the head." It is, after all, a short-sighted and expensive expedient, as the greater part of the value of the mineral is consumed by the expenses of raising the water and ore, to say nothing of the cost of delays which happen whenever the water comes in larger quantities than usual by a feeder being cut, and everything is interrupted for the time being. After what has been said already, it is hardly necessary to add that the proper mode of dealing with even these small deposits is to sink the shaft at first to a proper depth, and then to drive levels underneath the orey ground, which may then be removed by one or other of the different systems in use.

2.—The shafts and levels must be arranged in such a manner as to make the carriage or transport of the ore economical. If the works are badly kept, or a large portion is open at one time at a place whence there are no convenient means of access to the shaft, such proceedings may interfere seriously with any remuneration being obtained. This is more obvious in a colliery than in a metalliferous mine, but it is obvious enough in both, inasmuch as the rate of transport underground is immensely higher than at surface. This consideration makes it important to improve and shorten the routes as much as possible.

3.—The ventilation of the working places must be carried forward as perfectly as possible, both with the view to the saving of time, to economy, and to prevent danger to the health and lives of the workmen. For instance, if we take the case of a level 150 fms. from the surface, driven very much in advance of the other levels, which is often the case, the ventilation will be found extremely difficult to deal with, so as to enable the men to work satisfactorily, and without injury to health. The natural remedy in such a case is to sink a winze or shaft to the nearest workings, or in other cases to mitigate the evil by procuring the use of a ventilating machine. It is obvious that in a bad atmosphere the health of the workmen must suffer, and whenever a shot is fired there will be a great loss of time in waiting for the smoke to disperse, unless it is carried away by ventilation.

4.—The most important point in all mining operations is that preparatory or exploratory levels, both on the strike or the dip, should be carried on, while the other portions are being worked out. When this is fairly done great lengths may be opened in poor ground without being so serious a charge as they will be if not counterbalanced by profitable works in other parts of the mine. Take, for instance, the case of a small mine with two shafts, if the manager has not a proper degree of prudence and forethought he would constantly find a great tendency to remove the ore, and to neglect the duty and avoid the expense of sinking other shafts and driving other levels. As soon as this neglect sets in the closing of the mine begins. It often requires much courage as well as foresight, for it frequently happens that the manager will be sinking shafts and driving levels for years beforehand until, perhaps, the good ground is nearly exhausted. If he does not do so, however, he will be obliged to fall back on the company or proprietors for fresh capital, and if all the ends are getting poor at once no one will be induced to go on with such a mine. On the other hand, if exploratory levels have been already driven it will commonly happen that a fresh course of ore will have been discovered, or in any case a more favourable appearance, with which the owners will gladly go on till something better is met with. This is a case which often occurs. When we hear of this "tut," or "dead work" not being pushed at times when the mine is doing tolerably well we may be sure the owners are (though, perhaps, unwittingly) destroying their mine. Experienced captains of mines are perfectly aware when they are doing right in this respect, but it often happens that their hands are tied, and they are obliged by the owners to work the mine in a particular way. It is in consequence of this that many mines come to a standstill, which when resumed by others will pay very well, and it not unfrequently happens that mines are abandoned and resumed two or three times, each new attempt involving a great expenditure of capital to put them right again, which might have been saved if the mines had been worked from the first with a due consideration of the future. It is difficult to say what proportion the dead work should bear to the other. It will necessarily vary, according to circumstances. In the mine of Crœvecœur, in Bohemia, the proportion of men cutting away is one third to two-thirds constantly employed in opening new ground, or dead work. Unless this had been done in the Levant Mine large tracts of dead ground would never have been passed through, and valuable masses of rich ore never obtained. These are facts that ought always to be kept in view.

5.—The working places should be so disposed that the largest possible number of men can be brought to bear on them at once without any crowding. Even if it were for ventilation only, it is bad policy to crowd a limited portion of the works with too many men, who hinder and interfere with each other. This is a point sometimes very hard to manage in metalliferous mines, as if the mine happens to be poor, and in one part of the vein good ore is met with, the managers are too apt to crowd the men into that part, and get all they can from it.

6.—Great endeavours should be made to extract the whole mineral without waste. In metalliferous mines this is best done by setting the ground on the system of "tribute," in which it is the interest of the men to prevent waste, and to examine the ground with care, that none of the ore may get among the rubbish. In certain localities it may be absolutely necessary to leave valuable mineral behind, for the safety of both men and mine. At the Levant Mine a case in point occurred. At a comparatively shallow level, far out under the sea, a great outcry was raised that the water was coming in. The captains proved beyond doubt that there was a considerable quantity of salt water going into the mine; but as this was an old and known "feeder" there were no fears for its immediate safety. The tin ore being in that part very good, but surrounded with hard and difficult rock, the miners had been allowed to work upwards, towards where there might be risk. It was determined not to go further in that direction, and the managers put in strong timbering to prevent any further settlement, and ceased to work in that particular spot. There is always risk where a vertical fissure occurs, and where by taking away the ground the crust between the miners and the sea becomes weakened, or where a lode is inclined at a considerable angle, and it is difficult to replace its excavated substance by built pillars. Although the lode may consist of good masses of ore, it may be advisable to make some sacrifice by leaving arches of the unworked lode, rather than run the risk of the roof coming in. And in stratified deposits, where there is a bad roof, it may seem wasteful to leave one or two feet of good coal as roof, but balancing the expense of supporting that portion of the roof against the loss of coal by leaving it in the pit, the latter may be the most advantageous.

7.—Regard must be given to the settlements of ground at the surface, which damage or destroy buildings, perhaps villages or towns, produce large hollows or let in the waters of canals, rivers, reservoirs, and even the sea, and so occasion vast expenses for repairs and compensation, which may frequently be avoided or lessened by early remedial action. In cases of this kind either large masses of the mineral must be left as props, or replaced by artificial props of a permanent character. There are, however, many workings at which the material is removed from so great a depth that no damage to the surface need be apprehended.

In some parts of an extensive mine the excavations are thrown into a definite shape. Parallel levels (generally in Cornwall 10 fms. apart) being driven from the engine-shaft into the lode, the lower one will drain all the ground between, and that ground being orey, or good, the object will be to work it away. The older method adopted would have been by under-hand stopes. A winze is cut from level to level, and then the men begin in the uppermost one, at the corner nearest the winze, to work away a slice of ground under their feet, then another slice, and so on, each being kept back, and forming a succession of steps or stopes. In these workings the roof overhead has to be kept up by timber, and each stage supported by stemples. The material has to be removed by windlasses, and taken away, and the deads, or attle, has to be piled up out of the way, and so they advance step by step. The other, and the contrary, mode which has come into general use is what is called over-hand stoping. In this the work begins in the bottom level, and a piece about 6 ft. high being taken out, a transverse timber, supported by props, is put in, and a second stope cut. The advantages of this system are that the law of gravitation helps the work, and brings down the material, and the attle can be piled up below, on the stulls. There is also required a much less amount of timber; and whereas in under-hand stoping all the valuable material has to be raised by manual labour from below into the level, in the case of over-hand stoping, on the contrary, it has simply to be thrown down through certain small openings, or passes, left at various points for that purpose to the level below, into the wagons which carry it to the drawing-shaft.

I have considered both under the most favourable circumstances. If under-hand stoping be carried on below the bottom of the shaft—and there are instances in which injudicious managers have attempted it—the men have to fight with water, and can only do so under great disadvantages; and it, as well as the ore, will have to be raised by the windlass. Indeed, if you go into a mine and see a great many windlasses you may be sure the work is being improperly done, and that there is a likely prospect of the mine coming to a bad end. Under-hand stoping has, however, some advantages, as, for instance, when the ground is of considerable hardness, and the material valuable, like silver ore. In working very hard ground the men can use their strength with greater effect below than when they are delivering their blows upwards; and with silver, or other like ores of great intrinsic value, it is impossible when working over-hand to prevent it being trodden under foot, mixed with the attle, and lost. Then, again, the masses overhead are apt to break away, and when the lode is jointy and cracked it is in the highest degree perilous to the men who work beneath. Sometimes the material will break away in masses several tons in weight, and many lives have been thus sacrificed. On the other hand, that very jointy quality in the lode facilitates the work of the under-hand stoping.

QUARTERLY JOURNAL OF SCIENCE.—To the April number of this magazine Lieut. S. P. Oliver contributes an excellent article on Megalithic Structures of the Channel Islands: their History and Analogues; and Prof. P. Martin Duncan, F.R.S., has one on Insanity. Then follows an able history of The Metallurgical Industry of Cleveland, by the Editor, which is illustrated with some beautifully executed engravings; an abstract of this article will be found in the Supplement to this week's Journal. The Trophic Nerves are treated by Prof. G. Rolleston, M.D., F.R.S.; and Mr. E. Hull, director of the Geological Survey of Ireland, supplies an article on Recent Observations on Underground Temperature, or the Causes of Variation in Different Localities. The remaining original articles are on Mr. Bruce's Mines Regulation Bill, by the Editor; on Practical Scientific Instruction, by George Gore, F.R.S.; and on Atmospheric Electricity and Recent Phenomena of Refraction, by Samuel Barber. The Chronicles of Science are of the usual interesting and readable character.

THE SCIENCE OF BUILDING.—The advantage of combining scientific with practical knowledge is now so generally recognised that there is a gradually extending field for such works as that just issued by Mr. E. Wyndham Tarn, M.A., London (through Messrs. Lockwood and Co., of Stationers' Hall-court), entitled "The Science of Building." The work is specially intended for the architectural student, and has, therefore, been compiled in a style which will ensure its being generally understood by those whose mathematical knowledge is limited to an acquaintance with the elements of geometry and algebra. In the first two dozen pages he gives a vast amount of sound information relating to mechanical principles—indeed, all that is at all necessary for the thorough comprehension of the subsequent portions of the book. Retaining walls, arches, and cupolas, building stones, timber, iron, and water contained in vessels and pipes, have each a chapter devoted to them, and there is an appendix, consisting of a table of specific gravity and weight per cubic foot of building materials. The work is amply illustrated, and is calculated to prove of considerable value to all engaged in the arts of construction.

REDUCTION OF COPPER.—For the extraction of copper from its ores by the process of Dr. T. STERRY HUNT, and Mr. J. DOUGLAS, jun., of Montreal, it should be in the state of an oxide, or some compound thereof, as oxychloride or carbonate. The oxidised forms of copper are decomposed under proper conditions by proto-chloride of iron, with the production of dichloride of copper soluble in certain saline solutions, and in some cases a portion of proto-chloride together with insoluble peroxide of iron, and more or less insoluble oxychloride or basic persalt of iron, which may be rendered soluble by the action of sulphurous acid. The pulverised and naturally or artificially oxidised ores are to this end to be digested with a watery solution of neutral proto-chloride of iron, with or without the addition of an alkaline or earthy chloride, as common sea salt. The neutral protochloride of iron may be conveniently prepared by double decomposition of protosulphate of iron, with an equivalent of chloride of sodium or chloride of calcium. In preparing the solution the pro-

drain it. The 60 north is unproductive. We have set a rise in the 20 north to communicate with the adit level, in hopes of opening tribute ground. Our seven tribute pitches are a little improved on the whole, yielding a fair quantity of ore stuff.—Mioche: The adit north is in disordered ground, with scarcely any trace of the lode. The rise in the back of this level yields a little ore that will work at high tribute. The cross-cut east has met with irregular bunches of arsenical pyrites, but no lead ore. At Bouzarat we have met with a small vein in the adit cross-cut west, but nothing of the appearance of a regular lode. We are continuing to drive westward.—La Brousse: The sinking of Basset's shaft goes on regularly, but slowly; it will take yet two months to get to the required depth for commencing the 120 metre level. The 100 metre level north yields a low quality saving work. The same level, south on the main lode, yields ⅛ ton of ore per fathom. The 100, on the western part of the lode, is improved, and now yields ¾ ton of ore per fathom. The 80, 60, and 20 metre levels south are poor. In the 40 north we have effected a communication with the adit, thereby establishing good ventilation. We have resumed the driving of the level. Our tribute pitches yield fairly.—Pranal: The 70 metre level, south of cross-cut, is poor. The rise in the back of the same level north is in hard sparey ground; the lode yields stones of lead ore and blende. The 50, north of cross-course, is improved, and yields ½ ton per fathom. Our samplings have amounted to 278 tons.

ANGLO-ARGENTINE.—The directors have advices from Capt. J. Vivian, dated Gualilan, Feb. 15:—South Mine, Capitano: In driving the cross-cut east at the base of the hill, we have intersected the main lode, and cut into it about 2 feet; it is very compact, and has a splendid appearance. As soon as we have driven through it, so as to know its width and general character, I will write you at once and send you samples of the ore.

[For remainder of Foreign Mines see to-day's Journal.]

THE METALLURGICAL INDUSTRY OF CLEVELAND.*

Throughout the whole history of applied science and the metallurgic arts there is probably nothing which can at all compare with the condition of things now prevailing in Cleveland. In the more limited acceptation of the term, Cleveland is, strictly speaking, but a small portion of the North Riding of Yorkshire,—probably about one-third of it; but, from the fact that the staple industry is the same throughout a large part of Teesdale and South Durham as in Cleveland proper, the term has now popularly acquired a more extended signification. Within a very limited area of the district referred to, the last 20 years have seen an industrial development which has no equal, either in ancient or in modern times, at home or abroad An unusual amount of attention was directed to Cleveland in the autumn of last year, both by the iron and steel trades of the country and by the public at large, owing to the fact that the first provincial meeting of a new scientific association, bearing the name of the Iron and Steel Institute, was then held at Middlesborough, the capital of Cleveland. Owing to the vast amount of interest, both industrial and scientific, associated with Cleveland, it was highly proper that the first provincial meeting of the Institute should be held at Middlesborough. It brought together many persons to whom Cleveland was practically a *terra incognita*, and every facility was freely offered to them for the exploration of the district, so that they might have an opportunity of studying those features which had given to the district a history which, though brief, is perhaps the most eventful and interesting in the whole annals of the iron manufacture.

While the first stage of Middlesborough history commenced in 1829, the connection of the town with the great national industry of iron-making only began in the year 1840-41, when a rolling-mill and other works were erected for the manufacture of malleable iron on a small scale by Mr. Bolckow and the late Mr. John Vaughan. The former is a German, a native of Mecklenburg, and the latter was a man of indomitable perseverance and unflinching industry, whose practical acquaintance with iron-making had been gained while he was a workman at the world-famous iron works of Dowlais, South Wales. At the time just mentioned, and for some four or five years longer, Messrs. Bolckow and Vaughan brought their pig-iron from a distance and transformed it into bars, rails, castings, &c.; but in the year 1845 or 1846 they erected several small blast-furnaces at Witton Park, near Bishop Auckland, where they expected to secure a suitable supply of ironstone to keep their furnaces employed. The supply soon failed, and then they resorted to what was then known as Whitby ironstone, which they obtained on the Yorkshire coast, at Skinningrove, some 10 or 12 miles from Whitby. For a time they continued to work this Skinningrove ironstone, and carry it by ship and by rail, and at considerable expense, all the way to Witton Park to be smelted.

The third period of the history of Middlesborough and Cleveland began about the end of the year 1850, when the town of Middlesborough had a population of not more than 7000 inhabitants. It began with the discovery of the same deposit of ironstone almost as far inland from Skinningrove as Skinningrove is distant from Whitby, and quite within sight of Middlesborough. The difficulties of shipment were so great, owing to the exposed nature of the coast, that it was deemed very desirable to make a careful examination of the geological structure of the Cleveland Hills. It was in the year just mentioned that the search for the mineral proved successful, and the discovery has been the most eventful circumstance in the history of Cleveland. From the circumstance that the mineral was discovered there, it has since been known by the name of the Cleveland ironstone. Claims have been urged on the part of various persons as the discoverers of this famous mineral, as it has already, within the short period of 20 years, been largely concerned in effecting a great revolution in iron metallurgy.

The ironstone thus mined on the sea coast was shipped in large quantities to the iron works on the Tyne and Wear for a number of years before it was discovered inland. It is even stated that some of it was sent to the Tyne as far back as the year 1811. This, however, is certain, that John Vaughan was the first man to recognise the great industrial value of the inland deposits of Cleveland ironstone, and that to his practical knowledge is due not only the tentative introduction of the ironstone in 1850-51, but the present enormous development of the Cleveland iron trade, based, as it is, on the utilisation of those immense deposits of ore. After the employment by Mr. Vaughan of portions of the ironstone deposit of the Cleveland Hills, its enormous extent began to dawn upon the minds of geologists and mining engineers; and since then its distribution, position, and extent have been most carefully determined by Messrs. Marley, Bewick, Cockburn, Allison, and others. It is stating the facts in a very prosaic way to say that the Cleveland ironstone is deposited in such an enormous quantity as to be practically inexhaustible, and that the mining operations are now conducted upon a most gigantic scale. A few details bearing on these points may not be out of place at this stage.

The ironstone of Cleveland is an impure carbonate, but it does not belong to the carboniferous series of strata, as do the blackbands and the argillaceous or clayband ironstones. It occurs in some nine or ten seams, distributed chiefly through the Middle Lias group of the Oolitic series; but they are not all worked, nor, from a commercial point of view, are they all workable. The chief source of the ironstone which is at present being worked is the Main Cleveland Seam, the thickness of which is sometimes from 17½ to 20 feet, as at the Eston Mines. At other mines in varies from this extraordinary thickness down to 15, 11, and even to 7 feet. At the Eston Mines the ore is worked at a depth of nearly 600 feet from the top of the shaft, which opens out on a bleak and uninhabited Yorkshire moor. Sometimes the main seam is split up into two seams by shale and other beds, the upper being distinguished palæontologically as the *pecten* seam, and the lower as the *avicular* seam. Where the main seam is undivided it is generally richer in metallic iron than where it is split into two seams; in the former case the ore may yield from 30 to 31 per cent. of metal, while in the latter the yield is frequently from 28 to 26 per cent. of metallic iron. Cleveland ironstone is highly fossiliferous—indeed, it may be said to be quite charged with animal remains, and consequently there always occurs in the iron extracted from it a notable quantity of phosphorus, the presence of which has hitherto rendered the production of steel from it, without puddling, a scientific impossibility. Analyses of Cleveland pig-iron give not unfrequently from 1·2 to 1·3 per cent. of this troublesome element; and yet, although it is generally regarded as an undesirable ingredient of manufactured iron, it would almost seem that Cleveland iron, in the form of railway bars, has a greater degree of durability than iron which is practically free from phosphorus. Besides the seam referred to—the Main Cleveland Seam—there is another workable seam, known as the Top Bed. Geologically, it is from 230 to 250 feet higher up, resting on the top of the Upper Lias, the chief feature of which is the well-known Whitby alum shale. This Top Bed is only worked at three places—Glaisdale, Rosedale, and Port Mulgrave, on the coast. At Rosedale there is also a peculiarly deposited bed of rich magnetic ironstone, occupying the same geological position as the Top Bed just spoken of. It sometimes yields as much as 49 per cent. of metallic iron.

At first the Cleveland ironstone was generally quarried where it cropped out on the surface, but the plan now adopted is to sink shafts from the surface or drive levels from the hill-side, or both, and then work the mineral upon the "bord and pillar" principle. Some of the iron-smelting firms have mines of their own, others contract for their supply of mineral. As the mining operations of Cleveland are conducted upon such a gigantic scale, it is but natural to expect that no antiquated measures are adopted unless their utility has been fully demonstrated. To be "time-honoured" is not alone sufficient; they must be the most economical methods of procedure, both as regards the mineral to be worked and the labour and life spent upon it. One finds in use the most highly approved mechanical appliances, both for "winning" the mineral and for draining and ventilating the mines. As a single illustration it may be mentioned that in one of the mines explored by the present writer—one belonging to Messrs. Bolckow, Vaughan, and Co. (Limited), at Eston—the engine-plane was brilliantly illuminated throughout nearly a mile and a half with coal gas. The same plane is a level or drift which serves as an air-course inwards and a water-course outwards. The water is drained from the mine at the rate of about 600 gallons per minute, and is carried by gravitation to the company's blast-furnaces, where it takes the place of water, which formerly cost 1000*l.* per annum. The ironstone, which is the raw material forming the prime requisite of the great industry of Cleveland, is obtained so cheaply that it can be laid down at the furnaces at a cost of 4s. to 4s. 6d. per ton; and as it contains very frequently from 28 to 31 per cent. of metallic iron, the ore for a ton of pig-iron costs less than 14s. It is in a very great measure owing to the extraordinary abundance and cheapness of the raw ironstone that the Cleveland ironmasters have, in a comparatively short term of years, acquired for their district the proud distinction of being the greatest seat of the iron manufacture in the whole world. It was in the month of September, 1850, that the first sample of Cleveland ironstone from the Eston Hill was smelted at the Witton Park Iron Works; but it was only a few months afterwards that active measures were taken for the practical treatment of the mineral at Middlesborough, within easy reach of the ironstone deposit. Messrs. Bolckow and Vaughan were the first firm of ironmasters to enter upon the Cleveland industry.

In the Cleveland district the ironstone is in some instances calcined before leaving the mines, but in most cases it is calcined in very close proximity to the blast-furnaces where it is to be smelted. The operation is effected in calcining kilns, never in open heaps or "bings," such as may be seen in various iron districts. These kilns have no very distant resemblance to lime kilns. They are generally of very considerable size, sometimes 50 ft. in height, and upwards of 20 ft. in width; indeed, they are frequently a good deal larger than many of the blast-furnaces of South Staffordshire, South Wales, and Lanarkshire. The raw ironstone is raised to the top of the stacks of calcining kilns, either by inclined planes, up which the laden wagons are dragged, or by hoists of great ingenuity. As a rule, it is thoroughly roasted or calcined by means of 1 ton of small coal or "breeze" to from 30 to 40 tons of green ironstone. In every direction labour-saving appliances are to be found. Even in the discharging of kilns an ingenious hopper arrangement has been applied, which economises labour to a remarkable extent. The roasted stone is charged into great iron barrows without any shovelling being required, and by means of them it is lifted in the furnace-hoists to the top of the furnace, and charged into them quite hot. This plan of charging the furnaces with calcined ore while it is dry and quite hot also effects some economy in the fuel.

The blast-furnaces of Cleveland form quite an extraordinary feature throughout the whole district, whether we regard their number or their size, or the mode of working them. In no other iron-making district can such a sight be seen as that which meets the eye of the visitor to Middlesborough and the district immediately surrounding it. At the present time (February, 1870) there are no fewer than 122 blast-furnaces in the Cleveland district, if under that term it may be permitted to include Durham, considering that Cleveland ironstone is almost universally used in the blast-furnaces of that county. True, there are 12 of that number of furnaces that are not likely ever to be again brought into use in their present form, as they are too antiquated, and not in accordance with the prevailing notions as to what a blast-furnace should be. Then there other nine which are out of use, but as they are available they may again be called into requisition. There are thus left 101 furnaces, all of which are in blast; but besides these there are 14 new ones being built, one being raised, and other two being re-built or modernised. Somewhere about 70, or two-thirds of the whole, are clustered within an area so limited that a radius of three or four miles from the centre of Middlesborough would include almost every one of then. And then, such furnaces as they are in point of size, almost universally! Throughout Monmouthshire and South Wales there are probably not fewer than 200 blast-furnaces, while out of that great number only four or five reach to a greater height than 50 feet. Many of them are only 35 to 40 feet high, and there is even one that rises no higher than 25 feet. In South Staffordshire from 45 to 50 feet is the commonest height for the blast-furnaces, and in Scotland the greater of those two elevations is but seldom exceeded. But what a mighty difference is observable throughout Cleveland. Such a puny thing as a furnace only 45 feet high is exceedingly rare, and in comparison with many of the other colossal structures it might almost be spoken of simply as a crucible, or a tiny smelting-pot. Heights of from 70 to 95 feet are common throughout the whole district, while at Ferryhill there is one furnace that towers up to the extraordinary height of 103 feet, and is, therefore, doubtless the most gigantic iron smelting-furnace in the world. In the short space of 20 years Cleveland blast-furnace practice has passed through several phases. At first the furnaces were built only 45 feet high, then the height was increased to 56 feet, next to 60 feet, and then (in 1863) to 75 feet and soon afterwards still greater heights were adopted. Some of them had but very short lives, comparatively; they were erected and in use but a few years when it was resolved to raze them to the ground, and rebuild them of much larger dimensions. Amongst the new furnaces now in course of erection it is stated that there are two which are to be built to the height of 90 feet; and even the great furnace at Ferryhill is to be overtopped by one which is to reach a height of 120 feet! And as is the height of the Cleveland furnaces, so is their internal diameter at the widest part, or what is technically known as the "boshes." It generally varies from 16 to 25 feet, but in the case of the Ferryhill furnace it is 27 feet. The two 90-feet furnaces just referred to are to be 30 feet wide at the boshes, or one-third of the height; and it is proposed to make the 120-feet furnace no less than 33 feet wide at the boshes. Were the Vulcans and Tubal Cains of antiquity to revisit the earth, they would doubtless stare on coming within sight of these immense smelting crucibles. The internal capacity of some of the Cleveland furnaces amounts to 25,000 or 26,000 cubic feet—that of the Ferryhill furnace being 33,000 feet; and the weekly production of pig-iron from a number of the furnaces—fourteen castings, or two daily—is from 420 to 450 tons; at Norton it is as much as 550 tons, A single casting from one of the Ormesby furnaces has been known to weigh 45 tons. With furnaces which, together with their great number, have such a prodigious yielding power, it is scarcely to be wondered at that the Cleveland ironmasters are now making nearly one-third of all the pig-iron produced in Great Britain. One of them is the greatest individual maker of pig-iron in the world—Mr. T. Vaughan, of Clay Lane and South Bank Iron Works. His annual make is nearly 250,000 tons.

For a considerable length of time a vigorous and interesting discussion has been going on amongst the Cleveland ironmasters with reference to the maximum dimensions that may be allowed in the blast-furnaces consistent with a due regard to the highest degree of scientific economy in the working of the same. Mr. Isaac Lowthian Bell, who may, perhaps, be justly regarded as the greatest authority in the science and practice of iron-making amongst practical ironmasters, has taken his stand after having instituted probably the most elaborate series of experiments in blast-furnace practice ever made. The paper which he read at the Middlesborough meeting of the Iron and Steel Institute, "On the Development of Heat, and its Appropriation in Blast-Furnaces of different Dimensions," treats the subject very exhaustively. Mr. Bell obtained his data for calculations from furnaces of almost all capacities, ranging between 3500 and 33,000 cubic feet, and his verdict was that the most economical furnaces would ultimately prove to be those having capacities ranging from 12,000 to 25,000 or 26,000 cubic feet. There are, however, many ironmasters and blast-furnace managers who do not agree with the dictum pronounced by Mr. Bell, and there is a great deal to be said in favour of the assumption that the maximum limits have not yet been reached. In the opinion of Mr. C. W. Siemens, F.R.S., great results must be looked for rather by increase in the temperature of the blast than by simply increasing the capacity or height of the furnace. As a rule, every increase hitherto made in the heights of blast-furnaces has been attended with a saving of fuel, not in Cleveland only but in other iron districts also. For instance, by raising the height of some of the cold-blast furnaces at the Lilleshall Iron Works, Shropshire, from 50 to 70 feet, there was a saving of 7 to 8 cwts. of coal per ton of iron made. In the Cleveland iron-smelter's vocabulary the term "waste gases" is unknown. According to Mr. Bell, the system now in operation in Cleveland effects a saving of something like 600,000 tons of coal per annum in those works smelting the ironstone of North Yorkshire. Such scientific economy cannot fail to have important social and political considerations. The mode of closing the furnaces is generally the same in principle throughout the whole district; it is the well-known hopper-and-cone arrangement; and the gases are drawn off very near the top of the furnace, and conducted away by means of capacious tubes to be used in generating steam and in heating the air of the blast. Theoretically, there should be no coal used in either of these operations; they should both be accomplished by means of the furnace gases, and in practice this state of perfection is fully reached at some of the works. As coke is the fuel used in Cleveland, the combustible gas which is generated consists almost entirely of carbonic oxide, and it is the calorific powers of this gas which the iron-smelter has to utilise. Of course, there is also the atmospheric nitrogen of the air of the blast passing through the furnace. Of necessity, it absorbs a vast amount of heat, but of this heat it is well deprived before it is thrown back into the atmosphere. Since the hopper-and-cone arrangement of closing the furnace-top was generally adopted throughout Cleveland it has been very materially improved, especially by Mr. Charles Cochrane, of the Ormesby Iron Works, Middlesborough. His improved arrangement is that of a double-closed furnace-top, and has for its object the diminution of the amount of gas escaping from the furnace at the time of charging. It has done this so effectually that for one furnace the saving in fuel alone is equal to about 164*l.* per annum, while the necessary apparatus only costs 200*l.* In the hands of the Cleveland ironmasters the great invention which was given to the world by James Beaumont Neilson—the hot-blast—has of late almost revolutionised even Cleveland iron-smelting. Neilson seemed to think that he had arrived at the acme of perfection when he got the temperature of the blast raised to about 600° Fahr.; and in Scotland, where the invention had its birth, the blast is rarely heated much beyond that temperature. But in Cleveland, where no such deference is paid to old customs and traditions as they receive in Scotland and in South Staffordshire, there seems to be no resting place. Improvement succeeds improvement with extraordinary rapidity, and at present it is in the direction of increased temperature in the blast rather than in increase of furnace capacity that further economy is to be sought for. It is no uncommon thing in Cleveland to find the blast heated to from 850° to 1000° Fahr., but even the greater of those temperatures is not deemed sufficient. Under the leadership of Mr. Cochrane the tendency is still upwards. That gentleman has applied at the Ormesby Works the Siemens' regenerative system, as adapted by Mr. E. A. Cowper, C.E., F.R.S., for the heating of the air of the blast. He has of late used the blast at the unprecedented temperature of 1452° Fahr., and the result of his experience is that for each 100° the blast is raised there is a saving of 1·34 cwts. of coke per ton of iron made. It is the opinion of Mr. Bell that 20 cwts. of coke per ton of pig-iron is about the lowest minimum that can be attained; but Mr. Cochrame is sanguine that a minimum of 13 cwts. can be reached, provided that the blast is heated up to 2000°, and he has determined to aim at reaching that minimum consumption of coke, unless experience should prove it to be impossible to attain it. Even a consumption of only 21 cwts. of coke per ton of pig-iron must be deemed very marvellous, when it is remembered that twice that amount is employed in producing a ton of iron in cold-blast furnaces. There are instances of furnaces in the Cleveland district—Consett and Ferryhill—working on the consumption of 17 or 18 cwts. of coke per ton of pig-iron, but they are somewhat exceptional, as the ironstone used was either the rich Rosedale stone or not exclusively Cleveland stone, but a mixture of it with hematite, and, therefore, containing at first a much larger proportion of metallic iron than is customary throughout the district. Superheated air is also in use at Consett Iron Works, the temperature of the blast being about 1400° Fahr., and produced in a hot-blast stove, which is a modification and simplification of the Siemens-Cowper stove in use at the Ormesby Works. Report speaks very favourably of it as a fuel-saving appliance. The inventor of it is Mr. Thomas Whitwell, of the Thornaby Iron Works, Stockton.

From the facts already alluded to, and on account of the interesting scientific and practical problems which are at present being worked out, the eyes of all iron-making districts are anxiously directed to Cleveland. It is iron-smelting which really forms the staple industry of that district, and, although it is scarcely 20 years since it had its very small beginning, it is already of such enormous proportions that every other district is completely overshadowed by it. But although iron-smelting is *the* staple industry of Cleveland, it is not the only one. The manufacture of malleable iron is carried on to an immense extent throughout the district with great skill and energy, and it has called into requisition some 1400 or 1500 puddling-furnaces, possibly even more: and some of those furnaces are amongst the most economically effective appliances known to the metallurgist. In some of these the consumption of coal per ton of puddled bar has been reduced from 25 to 15 cwts. It was in Cleveland, likewise, that works were first erected by Messrs. B. Samuelson and Co. for the practical application of the Siemens-Martin process of manufacturing steel; and the experiments made by that firm at the Newport Works would seem to indicate that there is a great degree of probability that steel ingots for rails may yet be made at a price little exceeding that of puddled bar. This is not the place to enlarge upon the fact, but it may be stated that in the Cleveland iron trade two great social problems have been solved—the prevention of strikes and lock-outs, by the establishment of a Board of Arbitration and Conciliation; and the possibility of the co-operative system being carried out in a large iron-making establishment, the employees participating with the capitalists in the division of the net profits of the business. This system has been in operation during three years at the works of Messrs. Fox, Head, and Co., and it has just been resolved to continue the arrangement for the next five years. Great scientific and industrial results have been accomplished by Cleveland already, but it is not to much to expect that she has in store other equally great, if not greater, triumphs for the historian to record. The production of rails in Cleveland is at the present time not far short of 750,000 tons, and probably three-fourths of all the iron-plates used in shipbuilding are made from Cleveland iron. The readers of this Journal will recollect that brine-springs have been found under the town of Middlesborough; and there is every likelihood of the manufacture of salt being added before long to the other industries of Cleveland.

* Abstract of paper published in the "Quarterly Journal of Science" for April.

THE INSTITUTION OF CIVIL ENGINEERS.—At the meeting of members, on Tuesday, Mr. Charles B. Vignoles, F.R.S., President, in the chair, 19 candidates were balloted for and duly elected, including four *Members*—Mr. John Bailey, Dublin; Mr. William Elsdon, Melbourne, Victoria; Mr. Alexander Kendall Mackinnon, director general of public works, Monte Video; and Mr. Thos. Fothergill McNay, Westminster. Fifteen gentlemen were elected *Associates*—Mr. John Anstie, B.A., Westminster; Mr. John Collins Boys, Granville-place; Mr. Thomas Cargill, Beaufort-buildings; Mr. James Robert France, late acting engineer to the Submarine Telegraph Company; Mr. H. Gaerth, Westbourne-park-terrace; Lieut. George Edward Grover, R.E., Woolwich; Mr. David Gravell, student Inst. C.E., contractor's staff of the Sucsawa, Jassy, Roman, Bottuschany Railways in Moldavia; Mr. Frank James, Princess-street, Commercial-road; Mr. Joseph Kincaid, B.A., St. James's-street; Mr. Henry Ernest Milner,

late engineering staff, Windsor and Annopolis Railway; Mr. Thos. Newbigging, manager of the Rossendale Union Gas Works, Bacup; Mr. Ernest Bengough Ricketts, engineer's office, Trinity House; Mr. Frederick Warburton Stent, Westminster; Mr. Edward John Tatam, Moulton, near Spalding; and Mr. Clarence Edward Trotter, student Inst. C.E., Westminster. The following candidates have been admitted *Students* of the Institution:—James Hall Blake, Massey Bromley, B.A., John Henry Eykyn, Alfred Fyson, James Gilchrist, James Henry Greaves, Hilin William O'Neale Neale, William Patten, Robert Pickwell, and Charles Graham Smith.

The Royal School of Mines, Jermyn Street.

MR. WARINGTON SMYTH'S LECTURES.

[FROM NOTES BY OUR OWN REPORTER.]

LECTURE XXXIV.—We have now (said Mr. SMYTH) devoted some attention to the shafts and their security, and we naturally consider next the means by which they are traversed by the men in going to and leaving their work. In the early stages of mining, or when the depths penetrated are inconsiderable, these do not constitute a matter of much importance, but as the shafts become deeper, and the works below more extensive, so that the labour of large numbers of men is required, the mode of descending and ascending becomes highly important, both as regards the safety of the men and the economy with which it is carried out. When we look at the mining districts of Europe at large, we find that the depths are constantly increasing from which the mineral has to be raised, and to which the men have to descend, and, therefore, that is a matter which has to be considered with much greater care than formerly. It is only 30 years ago since it was considered an extraordinary thing that a coal mine shaft at Monkwearmouth should be sunk to a depth of 300 fathoms, or 600 yards; and it remained the wonder of the day for 15 years; and then that depth was exceeded by the famous pit at Dukinfield, in Cheshire, which went down to 700 yards. Now, however, that has lately been exceeded by a pit at Rosenfield, near Wigan, which is 800 yards, so that in this country we have advanced greatly. If we look at foreign countries we shall see a similar state of things. In Belgium, for instance, the pits used to be no more than from 300 to 500 metres; then they advanced to 600 and 700, and in one case recently a depth of 1000 metres has been reached. In metalliferous mines great depths have been reached, and in the district of Przibram, in Bohemia, they have attained a depth of 300 fms., and in some cases considerably over that. In the Hartz, again, the Samson Mine, near Andreasberg, is worked at a depth of 400 fathoms.

The greater difficulties which result from the increased depths of our mines are sought to be met by improved machinery, and by its extended application; before considering which we will look a little at the less artistic contrivances of earlier days. Whatever occurs in the actual working of shallow mines will frequently occur on a small scale in parts of large mines, whilst the principal shafts are ascended and descended by the more elaborate arrangements of modern times. There is, however, a great difference between collieries and metalliferous mines in this respect. The shaft of a colliery, as you have seen, is invariably sunk vertically, to meet the band or seam to be worked, and machinery is put up to raise the material and the men through that shaft alone, there being no subsidiary workings of the same kind, except, perhaps, some openings in the workings themselves, fitted with ladder-ways for the men to get through. But in metalliferous mines the latter are not exceptionable, but are going on constantly. You will see by the longitudinal section of a large metalliferous mine [exhibited] that there are a great many communications from one level to another, above or below, called "winzes." Through these the material has to be raised to the level most convenient, and, besides, there is the work going on through the principal shafts. Now, the winzes require some sort of mechanical arrangement by which the mineral or the men can be raised through them, and which are usually of the same character as those used in the earlier stages of the mine. In the old book of Agricola there are portrayed all the various methods in use in his time for descending underground. First of all we may take ladders, which even now are much used in some districts, and with advantage, when well constructed, and placed at a convenient angle of inclination. Next we have a representation of men being lowered by a windlass, seated on a small cross stick. In another plate the excavation is slanting, at an angle of 30 to 40°, and the men slipping down on a sort of sled, with a rope to lay hold of to steady them in their descent; and then, lastly, we have a series of steps cut roughly in the rock, which not only answers the purpose of sending the men down, but enables the horses to be taken down into the mine also. Steps of this kind are employed to this day in some of the great lead mines of the North, where circumstances have allowed them to put down a winding staircase, and in some of the districts of mountain limestone a similiar arrangement is carried out. Other cases may be quoted in the collieries of Flintshire; and no one can help admiring the extremely convenient arrangements, almost amounting to luxury, at the salt mine of Wieliczka, near Cracow, where steps not less than 6 feet wide are constructed, forming a staircase which descends at a very convenient angle of inclination; and down in the mine itself they have steps cut into the solid rock-salt, looking something like marble steps. I should here mention another case of great comfort and security, that of the admirable arrangement of the descent at the mine of Monte Catini, in Tuscany, which I have mentioned before, where the entrance of the men is provided for by having steps cut at convenient angles, winding down to the levels, and at any place where there is a chance of a break down the roofs are all carefully lined with arched masonry. These are comparatively exceptionable mines, which are expected to last a long time, and in which no expenses are spared for the comfort and security of the men, that being, in the long run, the best economy. I do not say anything about raising the men with a rope, as in the first stages rough and ready expedients of this kind are not dangerous, and save time, and thus the men mostly go down astride of a stick, or in the kibble by which the mineral is raised. In sinking winzes the same thing is usually done, and away from the main shaft, the convenience of these methods must depend on collateral circumstances, such as the strength of the ground, and the inclination of the seam or lode. Where there is a considerable inclination the men are half pulled up and half walk up, and many modifications of these plans are in use. In some of the Spanish mines, from an undue regard to economy, and to save the wages of the windlass men, the greater part of the miners are lowered, sometimes with one foot in the kibble and the other out, sometimes with one foot in a stirrup-iron, or loop, attached to the rope, holding on higher up—a most dangerous practice. A law has, however, been passed to the effect that no one shall be lowered unless secured by a strap round the body, so that if the miner lost his balance he would still be kept in an upright position. When the depth becomes as much as 20 fathoms methods of this sort are thrown out of use; and a practice has arisen for the men to go up at the point where the mineral is raised, and where, consequently, the machinery can be used for lowering or raising them. If we consider the enormous amount of manual labour required to raise the quantities now commonly brought up in a day from a depth of 300 to 400 yards, we shall see that it would be out of the question to trust to that kind of labour, and that machinery is indispensable; and the machinery being there, it is obviously better for the men to be lowered and raised by its power. Ladders, however, are the usual means of descent where machinery is not employed. These vary a good deal. In the smaller lead mines of the North of England and in Derbyshire they have very rude methods of descent. In many cases the ladders are simply pieces of wood projecting from the sides of the shaft, driven in between the stones of the walling. A great inconvenience attends this plan, as there is often a strong draught, which may extinguish the light carried by the person descending, and then if two or three of these pegs be worn or knocked away in succession he is exposed to great peril. The next step to this is putting in stemples, which are placed across at 4 feet asunder, sometimes parallel and sometimes transversely. In the winze, were it is not more than 2 or 3 fathoms deep, these are very suitable, and thus, instead of by regular ladders, the men climb up and down by the help of a rope. When, as in Yorkshire, the stemples are placed where the depth is from 40 to 50 fathoms, it is very hard work, and they are so large for the hands that those accustomed to a good ladder will not approve of them. The simplest kind of ladders proper are those in use in America, Hungary, and in some parts of the North of Europe, and they are a kind which are most advantageously employed when blasting is going on, and when, consequently, smaller ladders would be knocked to pieces. They are formed of a strong beam of wood, in which the steps are cut at proper distances. Another sort is very often used (although it is not to be recommended where there are a great number of men), in which strips of wood are nailed across an upright, like a poultry ladder, and placed against the sides of shafts for a considerable height. Wherever it is used means ought to be adopted for fixing the cross bars securely. The staves of the ladders in Saxony are usually flat, and are put through holes in the side pieces. In England they are usually round, and made of ash; with, in Cornwall, at the distance of every ten or eleven a strong wrought-iron stave, which holds the ladder firmly together. As a rule, iron staves are not advisable, and in winzes and places not often travelled through they will sometimes be found to have utterly perished, so far as strength is concerned, nothing being left but a mere crust. The distance at which the staves are placed asunder is a question which greatly affects the comfort of the men. If they were as close as those of a bricklayer's ladder no one would like them. It is usual in mines to have them from 10 to 12 in. apart; 12 in., however, are found to be a great pull upon ordinary legs, and 10 in., on the other hand, is too short a distance; 11 in., therefore, will be found as a rule to answer best, and that rule is generally adopted in Cornwall. Ladders are sometimes made of chain, for the purpose of being used in winzes, and are so far convenient that they can be raised from places where they are but seldom wanted, and removed elsewhere. It has been proposed in Belgium to substitute for ladders wrought-iron staircases, of a spiral form, winding round a perpendicular centre; and that plan might be useful when any accident happens to the machinery by which the men are raised and lowered. Thus cases occasionally occur in which the men, 100 or 200 in number, are left at the bottom for a whole night, or longer, because an accident has happened to the machinery, who might have ascended had there been a ladder-way.

Although it is to be hoped that ladders will some day be almost entirely superseded in regular work, and only retained for these exceptional cases, they are yet so numerous and general that it is a question of great importance to the mining engineer to consider how he may best place them. If we have an inclined shaft 250 fms., it is convenient to put the ladder along the footwall of the lode, but not close to it, so that any rubbish falling may pass through. In vertical shafts the ladder must be placed at an angle which is easy to climb, although a great deal will depend upon the size of the shaft. This is a subject which requires great care. At this moment a great number of our mines have the ladders placed so badly that where there are considerable distances to climb the health of the men is most seriously injured. It must always be remembered that these things are better done properly at first, as it would cost a great deal of money and time to take out a set of ladders and replace them with better. The worst ladders are those which rest upright against the wall of the shaft, of which there are not now so many cases as there used to be. A daily ascent and descent of 50, 60, or perhaps 80 fms. upon a perpendicular ladder is found to affect the heart and lungs very powerfully and injuriously, besides the danger of instant death by missing hand or foot hold. In such a case, the centre of gravity being outside the ladder, the unfortunate miner falls clear, and is dashed to pieces; whereas if the angle of inclination is sufficient he falls upon the lower part of the ladder, and has at least the chance of grasping some of the rounds. It is now, therefore, considered necessary to give an angle of inclination (say) of 75°, which a man in good health may use without great exertion, and without prejudicial effect upon the heart and lungs of any kind, besides which such ladders are much less dangerous. The question, then, is how to get that angle where the shaft is perpendicular. This is done by a system of sollars, or platforms, by which the descent is divided. Each of these sollars has a man-hole, with a trap-door, so that in case of an accident a man would not have a fall which must necessarily be fatal. In the Hartz and in Norway, where everything is done that is possible to be done for the health and safety of the workmen, very short ladders are used, the length being not more than 2 fms., and each sollar is well guarded with sides. In Saxony and Cornwall lengths of 4, 5, and 6 fms. are common. In the ordinary run of English mines from 20 to 40 fms. are the lengths which prevail. These long lengths, however, are all more or less painful and fatiguing, and in the deeper mines the average life of miners is shortened in consequence of this nearly as much as by the vitiated air they breathe, and other reasons, so that many plans are proposed to get rid of this labour. A great point in the problem is the consideration that the men are working at various depths on different levels, some at the bottom, and others, it may be, half-way up to the surface, so that while some have long others have short distances to climb.

For some years past, and in the last 30 years especially, this fact also attracted attention—that a vast deal of labour is expended in the mines by the men which might be saved, and their physical powers not worn out before their time. Thus, if we suppose the case of a shaft 1000 ft. deep, that 500 men are employed below, and that the average weight of the men is 120 lbs., each man will have to raise his own weight, and thus lift $500 \times 120 \times 1000 = 60{,}000{,}000$ lbs. 1 foot high. It is reckoned that 1,000,000 of foot pounds is a good, or rather a hard, day's work for a man, and thus 60,000,000 lbs. represents 60 days' labour. If the value of that be put only at 3s. there will be 9*l.* wasted every working day by the men having to climb from the bottom to the top, to say nothing of their going down. Reckoning 300 working days, the loss per annum is 2700*l.*; and if that be taken at 4 per cent. it will represent a capital of 60,000*l.*, which, if put into machinery, would bring the men to the surface in ease and comfort, and save them from diseases of the heart and lungs, from which they are grievous sufferers. About 1830, considerations of this kind began to produce practical results both in the Hartz and in Cornwall, and a satisfactory apparatus was hit upon almost simultaneously by Mr. Oppenheim in the former, and Mr. Lewis in the latter, and called "fahrkunst" in Germany and "man-engine" in Cornwall. It was first used at the Samson Mine, in the Hartz, and its advantages were so obvious that it was soon applied to other mines. In Cornwall it was first adopted at the Tresavean Mine, and it is used in many mines, but it has made far greater way on the Continent than with us. This machine when first erected was a little more complicated than it is at present. The idea suggested itself in this way. The ladders were placed between the pump-rod, and in ascending the ladders one day, Mr. Lewis thought how great a thing it would be if a lift could be attached, and he could ride up the length of the stroke of the rod, and then up the next, and so on to the top. A piece of paper was nailed to the wooden rods, and it was at once seen to be the right principle. A model was made, and then it was applied to actual circumstances. Steps were attached to two pump-rods, and the man going up would step at the end of its stroke from the one to the other, and so by a succession of lifts be taken from the bottom to the top as quickly as the number of strokes per minute done by the pumps. The same action reversed brought the men down. This was the principle of the double man-engine and of the fahrkunst. At first few men only would travel in this way, for the shaft being open and unprotected it required a good deal of nerve to step across the yawning chasm beneath.

Sollars and hand-rails at the places of change were then brought into use, and eventually the whole of the ascent and descent was effected in this way, with rapidity and safety. Subsequently the man-engine was constructed, with a single rod; and the up and down platforms on which the men ride being made at the end of each stroke almost to touch, the step from the one to the other is made without danger. In some places the engine is enclosed, so that if anyone did fall it would only be from one sollar to the other, or the length of the stroke. These in England are about 2 fathoms apart, and as the engine makes 8 strokes in a minute the rate of ascent or descent is 72 ft. in a minute. This is an immense boon to the men, and where their numbers are considerable a great advantage to their employers. The cost of the single man-engine is not large—something like from 1500*l.* to 2000*l.* for a depth of 250 fms.; and its use, therefore, it could almost be wished, should be made compulsory in all shafts of 100 fathoms or more in depth. It may be as well to mention that visitors and novices should be cautioned before travelling with these machines, as two or three lamentable accidents have occurred for want of presence of mind. It is some time before anyone not accustomed to the strange noises in a shaft, and those created by underground operations, feels sufficiently cool and collected to change his position at the right time. There might be danger, too, when going down in meeting a stream of men ascending; but when proper discipline is maintained, and the rules understood, one steps aside, and the journey for both is completed with security. The comfort and ease of the system, however, are so great that I have never heard of a single instance in which men still prefer to travel on the ladders to being lifted in this convenient manner.

LECTURE XXXV.—With regard to the different modes now in use of travelling through the shafts, it is much to be wished (said Mr. SMYTH) that we had some better statistics than any now available. It is of use to know the relative degrees in which one mode or the other have been adopted, and the efficiency and freedom from accidents of each. There can, however, be no question that in former days the mode of travelling by means of a rope when the shaft was unguarded was most dangerous, and that the number of accidents would tell unfavourably on that system as compared with ladders. Indeed, if a suitable mode of placing ladders be adopted, and precautions taken such as those described in the last lecture, there is no doubt but that it is one of the safest means by which the men can go their work and return from it, but then the wear and tear is great and exhaustive, and there is much want of economy. There are, then, a variety of reasons why there should be a thorough investigation into the subject, and why it is so much a matter of regret that we have not better statistics with a view of settling the relative advantages of different methods. When the mines are deep we have already seen the great advantage to be gained by applying the machinery already erected to the working of the fahrkunst, or man-engine; but it has been sometimes urged that as each man has to be taken singly there must be great delay, but there are really no grounds for this criticism. Every step of the machine is capable of taking a fresh man, and the whole may be passed through in a very short time; indeed, the length of each stroke represents a man, and the number of strokes per minute so many men per minute, and the calculation, therefore, is easily made for the whole complement; and then the machine-power is applicable all the rest of the day for other purposes. It is practically found that the time the engine is occupied is less than with the rope. Supposing there are 400 men employed in a colliery where the rope is used, it is doubtful if more than four men, and certainly not more than eight, would be allowed to ride at once. If we take eight, the kibble, or whatever it may be, will have to make 50 journeys in taking the men to work. Suppose each takes two minutes, and half a minute each in getting in and out, that makes 150 minutes, or two and a-half hours during which the machinery is thus occupied. Double that for raising the workpeople, and it is five hours per diem actually employed; and in many cases, when the sets do not go down regularly, the machinery cannot be employed in any other work. I am speaking of what is called slow time, but if the three minutes be abbreviated other dangers to some extent are introduced. Now-a-days in a colliery of moderate depth three-quarters of a minute instead of two minutes is occupied in the descent, and the speed is even greater in some. We have, however, no statistics as to the comparative risks of fast and slow winding, and either or both in comparison with the fahrkunst, or with ladders. The whole subject is one of growing importance: but it is a significant fact that the travelling-rods on the Continent have increased in number. The continental machines are more or less dissimilar to those employed in Cornwall. In some of the Prussian districts angular-iron has been employed in lengths of 20 ft. instead of wooden rods. These placed two and two make a combined rod, which, on the whole, is less heavy than wood, and has the advantage that the weight can be apportioned to the distance. Thus at a pit in the Ruhr district of Westphalia the upper rods weighed 176 lbs., the middle 170 lbs., and the lower 130 lbs. This is only one case quoted out of a number of collieries of moderate depth in which it is thought desirable to employ means of this kind to bring the men up. In the South Belgian coal field, at Mariémont, the men are carried with a great degree of rapidity and security by a machine constructed by M. Waroqué, upon what the French call the échelon movement. The shaft, which is 300 yards deep, is placed in the centre of a number of collieries, the men from which have access to it. It is fitted so completely that it is impossible for any accident to occur while the engine is working, and 700 people are lowered and raised per day. The shaft is elleptical, and the steps are so large (and have a rail round them) that two men may travel on each step. With respect to Cornish arrangements of this sort, they have the advantage of having the steps more nearly together, and so safety is secured. Another plan in use at Mansfeldt, in Prussian-Germany, said to work well, has the steps fixed at the four corners, and the men step off and on to platforms.

We will now turn to the subject of working away the main portion of a deposit, which is called the "working of mineral," in contradistinction to "winning," or laying it open, and for which the French have the term "exploitation," and by which they mean its removal on a large scale, when it has been prepared by other arrangements for that purpose. I have already shown you under what varying circumstances the repositories of useful mineral occur; how different is the character of roof and floor in different localities; the questions which are governed by the thickness, and whether the whole substance is or is not to be removed; and according to all these the nature of the work now to be considered will be varied. We will, however, confine ourselves to-day to metalliferous mines, and lodes of moderate size. We have now a portion of the work to do in which the general management comes into play to a greater extent than we have hitherto considered. The levels and shafts being completed, much depends upon the manner in which certain important considerations are kept in view, and certain indispensable rules or plans adhered to. It will be convenient to group these plans into several heads:—

1.—The workings must be so arranged as to keep them clear of water. This would seem an obvious and universal duty, but you will find very frequently in mines on a small scale that it is lamentably neglected. Thus, when they find the ore is going down the men are apt to remove that which looks the best, without reference to the future, and to cut it away in stopes, trusting to remove the water by manual labour; but the difficulty of raising the ore and the water increases with every foot they go down. The shaft may be only a windlass shaft, and if it has to be sunk lower the men will have to work in the water. The consequences are so well known, that getting ore in this way is termed "dragging it out by the hair of the head." It is, after all, a short-sighted and expensive expedient, as the greater part of the value of the mineral is consumed by the expenses of raising the water and ore, to say nothing of the cost of delays which happen whenever the water comes in larger quantities than usual by a feeder being cut, and everything is interrupted for the time being. After what has been said already, it is hardly necessary to add that the proper mode of dealing with even these small deposits is to sink the shaft at first to a proper depth, and then to drive levels underneath the orey ground, which may then be removed by one or other of the different systems in use.

2.—The shafts and levels must be arranged in such a manner as to make the carriage or transport of the ore economical. If the works are badly kept, or a large portion is open at one time at a place whence there are no convenient means of access to the shaft, such proceedings may interfere seriously with any remuneration being obtained. This is more obvious in a colliery than in a metalliferous mine, but it is obvious enough in both, inasmuch as the rate of transport underground is immensely higher than at surface. This consideration makes it important to improve and shorten the routes as much as possible.

3.—The ventilation of the working places must be carried forward as perfectly as possible, both with the view to the saving of time, to economy, and to prevent danger to the health and lives of the workmen. For instance, if we take the case of a level 150 fms. from the surface, driven very much in advance of the other levels, which is often the case, the ventilation will be found extremely difficult to deal with, so as to enable the men to work satisfactorily, and without injury to health. The natural remedy in such a case is to sink a winze or shaft to the nearest workings, or in other cases to mitigate the evil by procuring the use of a ventilating machine. It is obvious that in a bad atmosphere the health of the workmen must suffer, and whenever a shot is fired there will be a great loss of time in waiting for the smoke to disperse, unless it is carried away by ventilation.

4.—The most important point in all mining operations is that preparatory or exploratory levels, both on the strike or the dip, should be carried on, while the other portions are being worked out. When this is fairly done great lengths may be opened in poor ground without being so serious a charge as they will be if not counterbalanced by profitable works in other parts of the mine. Take, for instance, the case of a small mine with two shafts, if the manager has not a proper degree of prudence and forethought he would constantly find a great tendency to remove the ore, and to neglect the duty and avoid the expense of sinking other shafts and driving other levels. As soon as this neglect sets in the closing of the mine begins. It often requires much courage as well as foresight, for it frequently happens that the manager will be sinking shafts and driving levels for years beforehand until, perhaps, the good ground is nearly exhausted. If he does not do so, however, he will be obliged to fall back on the company or proprietors for fresh capital, and if all the ends are getting poor at once no one will be induced to go on with such a mine. On the other hand, if exploratory levels have been already driven it will commonly happen that a fresh course of ore will have been discovered, or in any case a more favourable appearance, with which the owners will gladly go on till something better is met with. This is a case which often occurs. When we hear of this "tut," or "dead work" not being pushed at times when the mine is doing tolerably well we may be sure the owners are (though, perhaps, unwittingly) destroying their mine. Experienced captains of mines are perfectly aware when they are doing right in this respect, but it often happens that their hands are tied, and they are obliged by the owners to work the mine in a particular way. It is in consequence of this that many mines come to a standstill, which when resumed by others will pay very well, and it not unfrequently happens that mines are abandoned and resumed two or three times, each new attempt involving a great expenditure of capital to put them right again, which might have been saved if the mines had been worked from the first with a due consideration of the future. It is difficult to say what proportion the dead work should bear to the other. It will necessarily vary, according to circumstances. In the mine of Crœvecœur, in Bohemia, the proportion of men cutting away is one third to two-thirds constantly employed in opening new ground, or dead work. Unless this had been done in the Levant Mine large tracts of dead ground would never have been passed through, and valuable masses of rich ore never obtained. These are facts that ought always to be kept in view.

5.—The working places should be so disposed that the largest possible number of men can be brought to bear on them at once without any crowding. Even if it were for ventilation only, it is bad policy to crowd a limited portion of the works with too many men, who hinder and interfere with each other. This is a point sometimes very hard to manage in metalliferous mines, as if the mine happens to be poor, and in one part of the vein good ore is met with, the managers are too apt to crowd the men into that part, and get all they can from it.

6.—Great endeavours should be made to extract the whole mineral without waste. In metalliferous mines this is best done by setting the ground on the system of "tribute," in which it is the interest of the men to prevent waste, and to examine the ground with care, that none of the ore may get among the rubbish. In certain localities it may be absolutely necessary to leave valuable mineral behind, for the safety of both men and mine. At the Levant Mine a case in point occurred. At a comparatively shallow level, far out under the sea, a great outcry was raised that the water was coming in. The captains proved beyond doubt that there was a considerable quantity of salt water going into the mine; but as this was an old and known "feeder" there were no fears for its immediate safety. The tin ore being in that part very good, but surrounded with hard and difficult rock, the miners had been allowed to work upwards, towards where there might be risk. It was determined not to go further in that direction, and the managers put in strong timbering to prevent any further settlement, and ceased to work in that particular spot. There is always risk where a vertical fissure occurs, and where by taking away the ground the crust between the miners and the sea becomes weakened, or where a lode is inclined at a considerable angle, and it is difficult to replace its excavated substance by built pillars. Although the lode may consist of good masses of ore, it may be advisable to make some sacrifice by leaving arches of the unworked lode, rather than run the risk of the roof coming in. And in stratified deposits, where there is a bad roof, it may seem wasteful to leave one or two feet of good coal as roof, but balancing the expense of supporting that portion of the roof against the loss of coal by leaving it in the pit, the latter may be the most advantageous.

7.—Regard must be given to the settlements of ground at the surface, which damage or destroy buildings, perhaps villages or towns, produce large hollows or let in the waters of canals, rivers, reservoirs, and even the sea, and so occasion vast expenses for repairs and compensation, which may frequently be avoided or lessened by early remedial action. In cases of this kind either large masses of the mineral must be left as props, or replaced by artificial props of a permanent character. There are, however, many workings at which the material is removed from so great a depth that no damage to the surface need be apprehended.

In some parts of an extensive mine the excavations are thrown into a definite shape. Parallel levels (generally in Cornwall 10 fms. apart) being driven from the engine-shaft into the lode, the lower one will drain all the ground between, and that ground being orey, or good, the object will be to work it away. The older method adopted would have been by under-hand stopes. A winze is cut from level to level, and then the men begin in the uppermost one, at the corner nearest the winze, to work away a slice of ground under their feet, then another slice, and so on, each being kept back, and forming a succession of steps or stopes. In these workings the roof overhead has to be kept up by timber, and each stage supported by stemples. The material has to be removed by windlasses, and taken away, and the deads, or attle, has to be piled up out of the way, and so they advance step by step. The other, and the contrary, mode which has come into general use is what is called over-hand stoping. In this the work begins in the bottom level, and a piece about 6 ft. high being taken out, a transverse timber, supported by props, is put in, and a second stope cut. The advantages of this system are that the law of gravitation helps the work, and brings down the material, and the attle can be piled up below, on the stulls. There is also required a much less amount of timber; and whereas in under-hand stoping all the valuable material has to be raised by manual labour from below into the level, in the case of over-hand stoping, on the contrary, it has simply to be thrown down through certain small openings, or passes, left at various points for that purpose to the level below, into the wagons which carry it to the drawing-shaft.

I have considered both under the most favourable circumstances. If underhand stoping be carried on below the bottom of the shaft—and there are instances in which injudicious managers have attempted it—the men have to fight with water, and can only do so under great disadvantages; and it, as well as the ore, will have to be raised by the windlass. Indeed, if you go into a mine and see a great many windlasses you may be sure the work is being improperly done, and that there is a likely prospect of the mine coming to a bad end. Underhand stoping has, however, some advantages, as, for instance, when the ground is of considerable hardness, and the material valuable, like silver ore. In working very hard ground the men can use their strength with greater effect below than when they are delivering their blows upwards; and with silver, or other like ores of great intrinsic value, it is impossible when working over-hand to prevent it being trodden under foot, mixed with the attle, and lost. Then, again, the masses overhead are apt to break away, and when the lode is jointy and cracked it is in the highest degree perilous to the men who work beneath. Sometimes the material will break away in masses several tons in weight, and many lives have been thus sacrificed. On the other hand, that very jointy quality in the lode facilitates the work of the under-hand stoping.

QUARTERLY JOURNAL OF SCIENCE.—To the April number of this magazine Lieut. S. P. Oliver contributes an excellent article on Megalithic Structures of the Channel Islands: their History and Analogues; and Prof. P. Martin Duncan, F.R.S., has one on Insanity. Then follows an able history of The Metallurgical Industry of Cleveland, by the Editor, which is illustrated with some beautifully executed engravings: an abstract of this article will be found in the Supplement to this week's Journal. The Trophic Nerves are treated by Prof. G. Rolleston, M.D., F.R.S.; and Mr. E. Hull, director of the Geological Survey of Ireland, supplies an article on Recent Observations on Underground Temperature, or the Causes of Variation in Different Localities. The remaining original articles are on Mr. Bruce's Mines Regulation Bill, by the Editor; on Practical Scientific Instruction, by George Gore, F.R.S.; and on Atmospheric Electricity and Recent Phenomena of Refraction, by Samuel Barber. The Chronicles of Science are of the usual interesting and readable character.

THE SCIENCE OF BUILDING.—The advantage of combining scientific with practical knowledge is now so generally recognised that there is a gradually extending field for such works as that just issued by Mr. E. Wyndham Tarn, M.A., London (through Messrs. Lockwood and Co., of Stationers' Hall-court), entitled "The Science of Building." The work is specially intended for the architectural student, and has, therefore, been compiled in a style which will ensure its being generally understood by those whose mathematical knowledge is limited to an acquaintance with the elements of geometry and algebra. In the first two dozen pages he gives a vast amount of sound information relating to mechanical principles—indeed, all that is at all necessary for the thorough comprehension of the subsequent portions of the book. Retaining walls, arches, and cupolas, building stones, timber, iron, and water contained in vessels and pipes, have each a chapter devoted to them, and there is an appendix, consisting of a table of specific gravity and weight per cubic foot of building materials. The work is amply illustrated, and is calculated to prove of considerable value to all engaged in the arts of construction.

REDUCTION OF COPPER.—For the extraction of copper from its ores by the process of Dr. T. STERRY HUNT, and Mr. J. DOUGLAS, jun., of Montreal, it should be in the state of an oxide, or some compound thereof, as oxychloride or carbonate. The oxidised forms of copper are decomposed under proper conditions by proto-chloride of iron, with the production of dichloride of copper soluble in certain saline solutions, and in some cases a portion of protochloride together with insoluble peroxide of iron, and more or less insoluble oxychloride or basic persalt of iron, which may be rendered soluble by the action of sulphurous acid. The pulverised and naturally or artificially oxidised ores are to this end to be digested with a watery solution of neutral protochloride of iron, with or without the addition of an alkaline or earthy chloride, as common sea salt. The neutral protochloride of iron may be conveniently prepared by double decomposition of protosulphate of iron, with an equivalent of chloride of sodium or chloride of calcium. In preparing the solution the pro-

cess may be as follows:—120 lbs. of sea salt (chloride of sodium), or 112 lbs. of dry chloride of calcium, or its eqivalent of hydrated chloride, are to be dissolved with 280 lbs. of protosulphate of iron (green copperas) in 100 imperial gallons of water. In place of the above salts may be substituted an amount of protochloride of iron prepared by any other method, and containing 56 lbs. of metallic iron. To the bath of 100 gallons prepared in either way 200 lbs. of common salt are then added, when the solution is ready for use, and will be found capable of chloridising about 90 lbs. of copper. The power of brine to dissolve the dichloride of copper found increases greatly with the strength and temperature.

MINING, METALS, AND MINERALS—PATENT MATTERS.

BY MICHAEL HENRY,
Patent Agent and Adviser, Memb. Soc. Arts, Assoc. Soc. Eng.

Messrs. THOMAS GIBBS and CHARLES GELSTHORP, of Jarrow-on-Tyne, Durham, have specified a joint invention for the extraction of copper from its ores. This invention relates to the extraction of copper from its ores, and is also applicable to the treatment of compounds in which copper may be combined after the same have been calcined with chloride of sodium or other chloride. After calcination with chlorides the ore usually contains, besides copper in such combination as to be soluble in water, a further quantity of copper, which has hitherto been usually extracted by means of hydrochloric acid, or of an acid solution obtained in condensing, by the agency of water, the gases from the furnace in which the ore is calcined. When such last-mentioned solution is used certain metals are generally present in it—such as, for instance, arsenic and bismuth are precipitated with the copper in the further treatment of the solutions obtained from the calcined ore by means of the solution in question. In order to use the solution in lixiviating the calcined ore without contamination of the copper contained therein, such metals are precipated before using the acid solution by means of iron, copper, or other precipitant capable of precipitating the same from an acid solution. It is proposed to use iron or copper in powder, the former in the state known as "spongy iron," being used as a precipitant for copper, and the copper employed may be copper precipitated by spongy iron or other means. The solutions of copper obtained in lixiviating ores after calcination with a chloride are usually digested on iron, in order to precipitate the copper they contain. The solutions so remaining after precipitation, and which are known as "iron liquors," are employed, in accordance with this invention, without an acid, or only in a slightly acidulated state, in the lixiviation of calcined ore, instead of hydrochloric acid or the acid solution above mentioned, for the removal of copper insoluble in water.

Mr. A. NEILL, of Bradford, has obtained a patent for machinery or apparatus for cutting and dressing, or producing an even surface on stone, marble, slate, or other substances; also for moulding or shaping and polishing such substances. The invention relates, firstly, to an arrangement and description of machinery for cutting and dressing stone and other substances to a required size, and producing a smooth and regular or even surface thereon, for which purpose is employed a revolving wheel or face plate, with either a vertical or horizontal axis, and a cutter fixed to the face of the wheel or face-plate. The material to be cut is placed on a wagon or travelling bench, constructed to pass in front of the wheel or face-plate, and such carriage may be constructed to move either continuously or intermittently at a stationary height, or adjustable to any height required; and it may be so constructed as to move in one line at a fixed distance from and parallel with the face-plate, or the line may be varied or variable, both as to distance and direction from the face-plate.—2. The invention relates to the cutting, grooving, or moulding of such substances. For this the stone, marble, &c., is fixed on the travelling bench, and is caused to move in front of a vertical face-plate, or underneath a horizontal face-plate. For the production of curvilinear works, &c., the tools, or cutters, are fixed on the face-plate at a distance from its centre equal to the radius of the groove, or mould, to be worked thereon. Stone or other material being fixed on the carriage, or bench, it is placed in position before the face-plate, and lateral motion given to the carriage to press the material against the cutters as the work proceeds. In grooving, or moulding, the cutters are fixed on the plate, with their cutting edges towards the circumference, and the material is fixed and adjusted on the carriage, or bench, to a suitable position for the cutters to operate thereon; the carriage is then moved forward, parallel with the surface of the plate, and also moved laterally, pressing the stone against the cutters as the work proceeds.—3. The invention relates to polishing stone, &c., and for this purpose a rim of iron or stone is fixed to the face of the plate at or near the circumference of the said face plate, so that it will revolve therewith. The material to be operated upon is fixed upon the travelling bench, the carriage travelling in face of the rim, sand and water, or other scouring matter, being applied betwixt the rim and the material; or this polishing may be effected by the stone being pressed against the revolving face plate with sand and water, supplied as before stated.

MANUFACTURE OF IRON AND STEEL.

The invention of Mr. J. J. JOHNSTON, of Philadelphia, consists in bringing melted metal direct from iron ore, or pig metal re-melted, into its most fluid condition, and then purifying and refining it by mixing with it a metallic oxide, and then forming it into plates or bars of wrought-iron by pouring the molten metal thus purified and refined, and while still in a fluid condition, into moulds formed of a metallic oxide, or moulds coated with a metallic oxide.

Mr. J. M. STANLEY, of Sheffield, also proposes to economise the consumption of fuel and reduce the cost of the metals in the manufacture of iron and steel. For effecting this object the inventor decarbonises the molten metal in crucibles formed and constructed as described in the specification, and applies the heat or gases given off during the decarbonising or converting processes, either alone or mixed with other gases or fuel, to the purpose of smelting ore or re-melting or heating iron or steel in a stack in connection with the crucible, or for carrying on the decarbonising or converting processes in the same furnace at the same time, and in part without fuel, except such as is contained in the metal. The crucible for converting or decarbonising the molten iron the inventor makes stationary, and cases it with cast or wrought-iron, or other suitable material, and lines it with strong fire-resisting material, such as fire-clay or ganister. The form inside is egg-shaped, with a dished bottom, having an opening therein, with a branch proceeding therefrom somewhat similar to the spout of a kettle, and lined with the same fire resisting material as the crucible. This branch or trunk may rise to any suitable height, so that the molten iron may stand at the same level in it as in the crucible.

Mr. E. A. COWPER, of Great George-street, proposes to accomplish the purification, or partial purification, of cast-iron by a jet of steam or superheated steam applied to a stream or jet of liquid cast-iron, so as to divide it up into small particles, and act extensively upon such particles for the purpose of purification, the iron being received in a hot box, and transferred to a calcining furnace, in which it is kept hot whilst still exposed to an atmosphere of steam or superheated steam, such purified iron being mixed either hot or cold with liquid cast-iron as it flows from the blast-furnace or other furnace, to be afterwards used as cast-iron, or made into steel or wrought-iron.

STEAM BOILERS.—By the invention of Mr. G. ALLIBON, of Northfleet, Kent, and A. MANBRE, Baker-street, they construct separately and as two distinct parts the body of the boiler and the fire-box portions, which are afterwards combined together; but, instead of having a central pendant pot or deep conical-shaped vessel, receiver, or pocket, as under a former patent, boilers constructed in accordance with the present invention have no such suspended pot or vessel, but consist wholly of a series of cylindrical or cylindrical and conical hoops or rings, combined together so as to form two or more concentrically disposed annular water spaces with a central combustion chamber or flame-box, and an annular down flue or flues between the water spaces. Thus instead of the central pendant pot, pocket, receiver, or vessel, whereby the central portion of the body of the boiler had a disproportionate weight and bulk of water suspended therefrom in a vessel, exposing to the action of the fire a comparately small area of heat abstracting surface in relation to the bulk of water contained within it, by the present invention is substituted for such suspended pot, receiver, or pocket a hollow vessel forming an annular water space pendant from and communicating at its top or upper end with the main body of water.

IMPROVEMENTS IN SMELTING.—The invention of Mr. J. BERNARD of Salisbury-street, Strand, consists in placing the material to be introduced into the furnace in a suitable receptacle forming part of a travelling or movable carriage or platform, the whole so formed, combined, and arranged that it can be readily introduced into the furnace at the proper place and time, suitable movements and arrangements being made for opening the furnace, moving the carriage in and out, and actuating its different parts by cams and levers, or other suitable mechanism, so as to cause the materials to be deposited or discharged at the proper time, and in the exact position desired.

OSLER'S CRYSTAL GLASS CHANDELIERS,

WALL LIGHTS and LUSTRES for GAS and CANDLES.

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MODERATOR LAMPS, AND LAMPS FOR INDIA.

TABLE GLASS of all kinds. ORNAMENTAL GLASS, English and Foreign.

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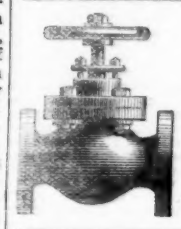

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FOR WATER, STEAM, GAS, ETC.,

Made by MATHER AND PLATT,

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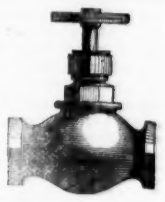

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FROM 4 TO 25-HORSE POWER.

THRASHING MACHINES,

Single, Double, and Treble Blast, with Patent Rolled Steel Beater Plates, and all other Recent Improvements.

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DRIVING LEVELS AND SINKING SHAFTS IN MINES,

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ARRANGEMENT FOR SHAFT SINKING AND QUARRYING.

In STONE of ORDINARY HARDNESS the MACHINE will BORE HOLES at the rate of about SIX INCHES in depth PER MINUTE, and in the HARDEST GRANITE at from TWO to THREE INCHES PER MINUTE. For this a working pressure of 30 lbs. only per square inch is required. In Quarrying and Shaft-sinking the stand is not required, consequently NO TIME IS LOST IN FIXING THE MACHINE.

This engine has been used with advantage in the mines of the Vieille Montagne Company in Germany, as well as in Belgium, and at Tincroft Mine, in Cornwall.

Twelve engines are now in course of construction for use in the Dolcoath Mine, in Cornwall.

For further particulars, apply to the sole makers—

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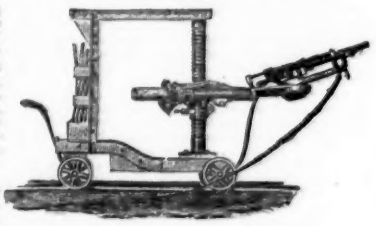
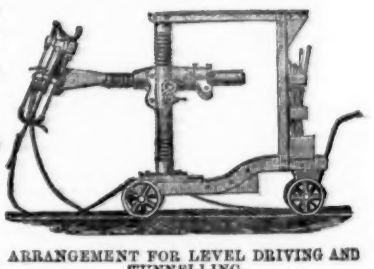
On whose premises a Machine can be seen in action.





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To the standard of any nation,
Suitable for every purpose, of any power and dimensions.

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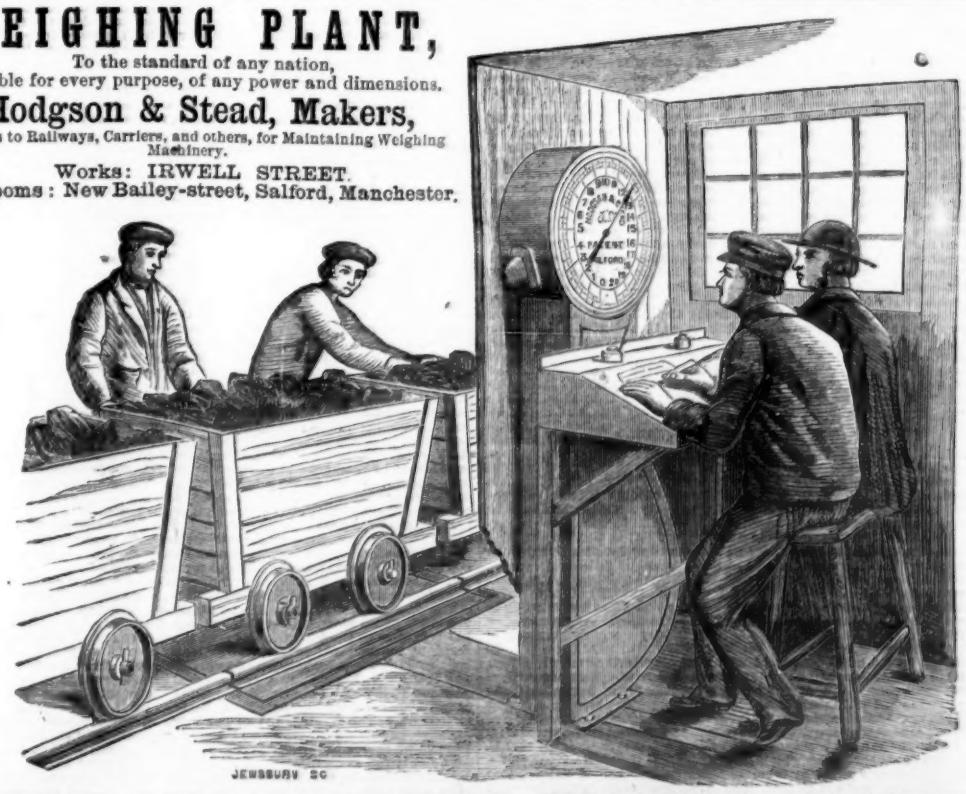

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Capable of WEIGHING TWELVE TUBS A MINUTE.

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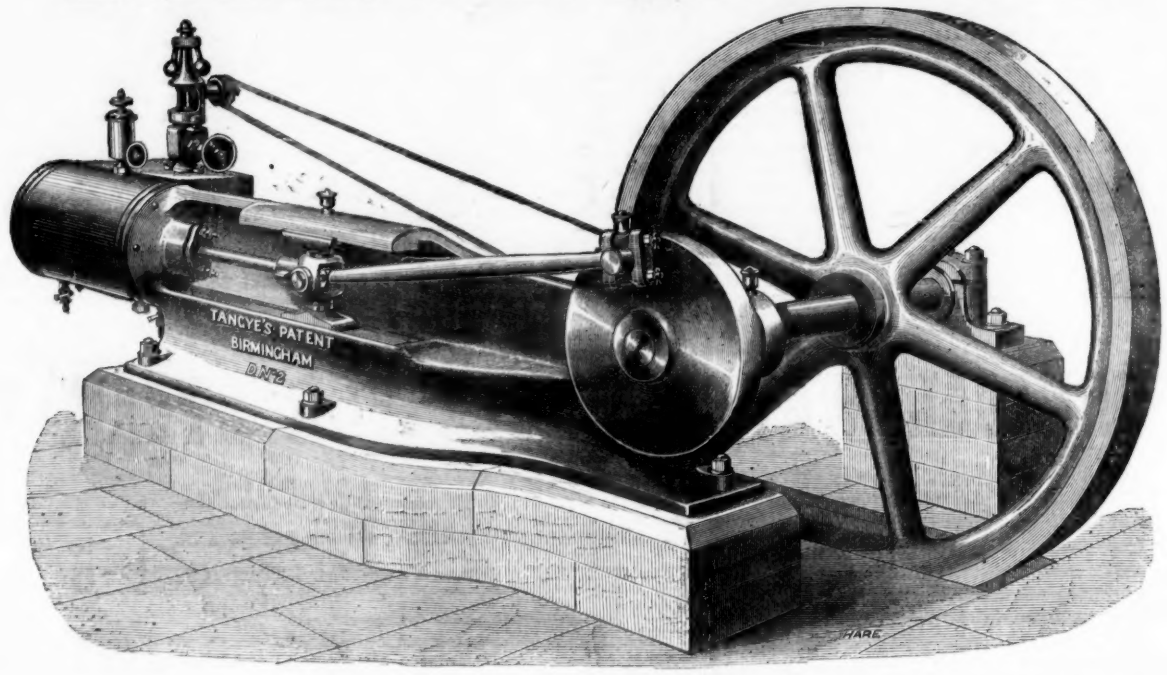
TANGYE'S

Patent High Speed Regulating Governor Steam Engines.

These Engines have been adopted by Her Majesty's Government for use at the Royal Gun Factories.



NEW DESIGN.
FIRST-CLASS WORK.
SIMPLE. STRONG.
GUARANTEED.

Number of engine	A	B	C	D	E	G	H	J
Nominal horse-power	One	Two	Three	Four	Six	Eight	Ten	Twelve
Price of Engine, with Governor and Feed Pump	£20	£27 10	£35	£40	£60	£80	£100	£120
Price of Engine and Boiler, with Fittings	£43	£56	£84	£96	£135	£168	£205	£235
Diameter of Steam Cylinders, in inches	3	4	5	6	8	9	10	12
Length of Stroke, in inches	6	8	10	12	16	18	20	24

EVERY ENGINE
WELL TESTED
BEFORE LEAVING
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THE "SPECIAL" STEAM PUMPS.

NOTE.

Each one is carefully tested with Steam and Water before leaving the Manufacturer.

In case of special quotations, the following particulars are required—viz.:

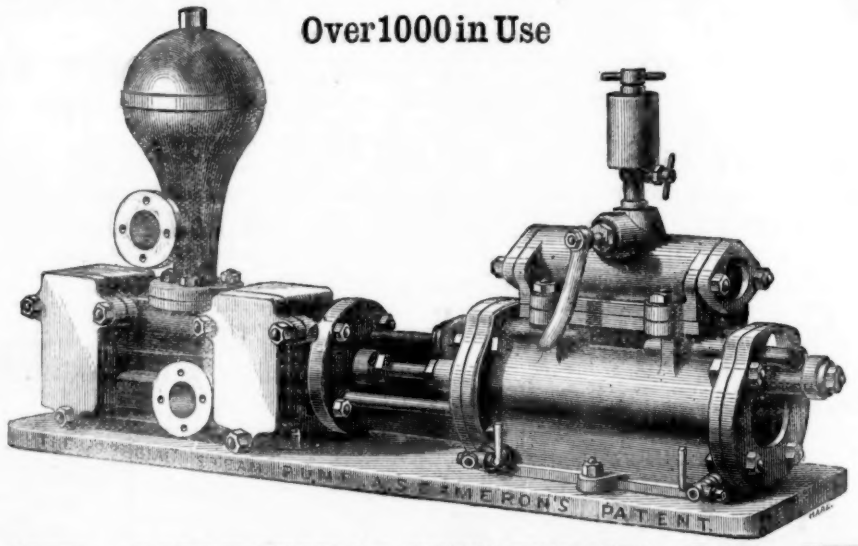
Pressure of Steam in Boiler.

The number of Gallons required to be lifted in a given time,

And the height of Lift from level of water to the point of delivery.

In ordering, state the purpose for which the pump is required, to ensure suitable valves being sent.

Over 1000 in Use



NOTE.

Requires NO Shafting, Gearing, Riggers, or Belts.

All Double-Acting.

Works at any Speed, and any Pressure of Steam.

Will Force to any Height.

Delivers a constant stream.

Can be placed any distance away from a Boiler.

Occupies little space.

Simple, Durable, Economical.

NO FLY-WHEEL, CRANK, GOVERNORS, CONNECTING ROD, GUIDE, OR ECCENTRIC.

Supplied to H.M.'s Arsenal and Dockyards at Woolwich, Chatham, and Devonport, also for use on board H.M.'s Ships, Hercules and Monarch.

FORTY THOUSAND GALLONS PER HOUR IS BEING RAISED 40 FEET HIGH AT MR. McMURRAY'S PAPER MILLS, WANDSWORTH, BY THE "SPECIAL" STEAM PUMP.

PRICES OF THE "SPECIAL" STEAM PUMPS.

Diameter of Steam Cylinder ....inches	2½	3	4	4	6	6	6	7	7	7	8	8	8	8	10	10	12	12	14	16	24
Diameter of Water Cylinder ....inches	1¼	1½	2	4	3	4	6	5	6	7	4	6	7	8	6	7	8	10	12	7	10
Length of Stroke ....inches	6	9	9	9	12	12	12	12	12	12	12	12	12	12	12	12	18	24	24	24	24
Strokes per minute	100	100	75	60	50	50	50	50	50	50	50	50	50	50	50	50	35	—	—	—	—
Gallons per hour	310	680	910	2900	1830	3250	7330	5070	7330	9750	3250	7330	9500	13,000	7330	9500	13,000	—	—	—	—
PRICE	£10	£15	£20	£30	£30	£40	£47 10	£50	£52 10	£57 10	£50	£55	£65	£75	£70	£80	£100	—	—	—	—

IF BRASS LINED, OR SOLID BRASS OR GUN-METAL WATER CYLINDERS, WITH COPPER AIR VESSELS, EXTRA, ACCORDING TO SIZE.

Any Combination can be made between the Steam and Water Cylinders, provided the Lengths of Stroke are the same, thus—8 in. Steam and 3 in. Water, or 10 in. Steam and 3 in. Water, adapted to height of lift and pressure of steam, and so on.

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Fig. 48. Fig. 146. Fig. 142. Fig. 22. Fig. 134. Fig. 106. Fig. 43. Fig. 86.

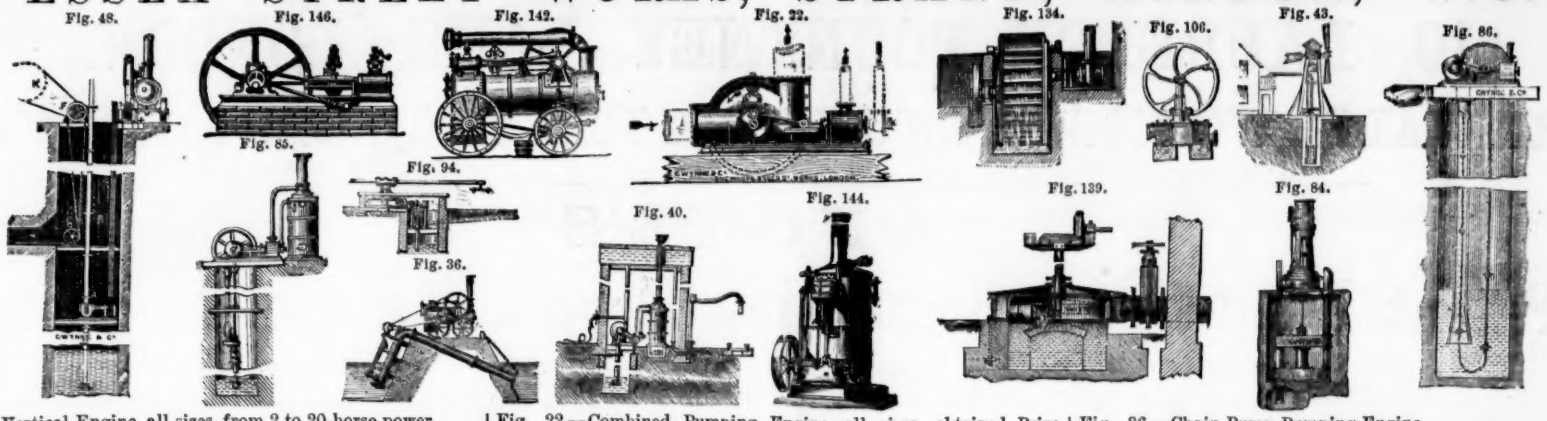


Fig. 85. Fig. 94. Fig. 144. Fig. 139. Fig. 84.

Fig. 36. Fig. 40.

Fig. 144.—Vertical Engine, all sizes, from 2 to 20-horse power.
Fig. 146.—Horizontal Engine, from 4 to 100-horse power.
Fig. 142.—Portable Engine, from 2½ to 30-horse power.
Fig. 40.—Gwynne and Co.'s Combined Stationary Pumping Engine.
Fig. 139.—Turbine Water-wheel, from 1 to 300-horse power.

Fig. 22.—Combined Pumping Engine, all sizes, obtained Prize Medal, Paris Exhibition.
Fig. 85.—Deep Well Pumping Engine, all sizes.
Fig. 134.—Water-wheel Pumping Machinery.
Fig. 36.—Gwynne and Co.'s Patent Syphon Drainage Machinery.
Fig. 95.—Horse-power Pumping Machinery.

Fig. 86.—Chain Pump Pumping Engine.
Fig. 48.—Deep Mine Centrifugal Pumping Machinery.
Fig. 84.—Double-acting Vertical Pumping Engine.
Fig. 106.—Gwynne and Co.'s Improved Plunger Hand Pump.
Fig. 43.—Wind Power Pumping Machinery.

Steam Engines of all kinds and sizes, Hand and Steam Fire Engines, Water Wheels, Hydraulic Lifts, Cranes and Jacks, Steam and Water Valves, Hydraulic Presses, Sheep Washing Machinery, &c., &c.

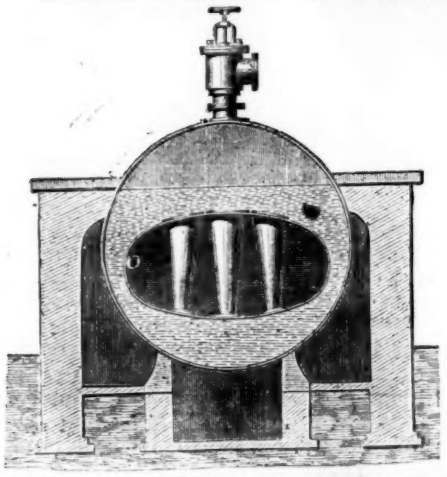
List of Centrifugal Pumps, two stamps. Illustrated Catalogues of Pumping Machinery, six stamps. Large Illustrated Catalogue, with many Estimates, &c., twelve stamps. All post free. GWYNNE and Co. have recently effected a considerable reduction in their prices, being determined to supply not only *the best* but *the cheapest* Pumping Machinery in the world.

GWYNNE AND CO.,

HYDRAULIC AND MECHANICAL ENGINEERS, ESSEX STREET WORKS, STRAND, LONDON, W.C.

GALLOWAY'S

PATENT CONICAL WATER TUBES FOR STEAM BOILERS.



Section of the "Galloway" Boiler, showing arrangement of back flues, the furnaces being of the same construction as in the common two-flued boiler.

The above TUBES are made with such an amount of taper as will allow the bottom flange to pass through the hole in the upper side of the boiler flue, which renders their introduction into ordinary flued boilers a simple operation, and with the following advantages:—

The POWER of the BOILER is CONSIDERABLY INCREASED, and the FLUES ARE MATERIALLY STRENGTHENED.

The CIRCULATION of the WATER is MUCH IMPROVED, and UNEQUAL EXPANSION, with its attendant evils, PREVENTED.

LIABILITY TO PRIME IS LESSENED.

These Tubes have now been in use upwards of fourteen years, and above 50,000 are in work in various parts of the country with the best results.

They can be fixed by any boiler maker, but can only be obtained from the Patentees,

W. & J. GALLOWAY & SONS,

ENGINEERS AND BOILER MAKERS,

MANCHESTER,

Makers of Wrought-iron Parallel Tubes, 40s. p. cwt.

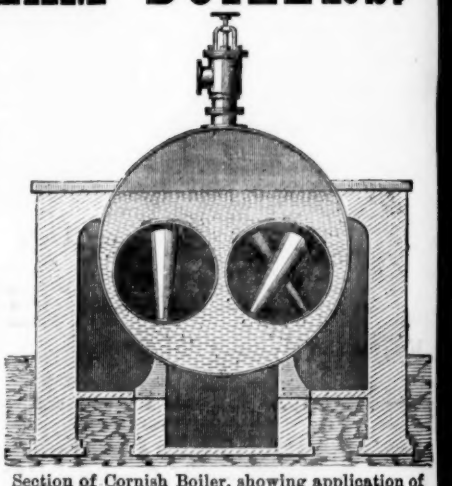
MANUFACTURERS OF THE WELL-KNOWN

"GALLOWAY BOILER,"

AS PER SKETCH ANNEXED.

UPWARDS OF TWO THOUSAND OF WHICH ARE NOW AT WORK.

BOILERS OF ANY DIMENSIONS, UPON THIS OR ANY OTHER PLAN, CAN BE DELIVERED WITHIN A FEW DAYS FROM RECEIPT OF ORDER.



Section of Cornish Boiler, showing application of the "Galloway" Tubes.

STEAM ENGINES OF EVERY DESCRIPTION.

General Millwrighting.—Hydraulic Machinery.—Polishing, Grinding, and other Machines for Plate Glass.

LEAD ROLLING MILLS AND PIPE PRESSES. CAST AND WROUGHT-IRON GIRDER BRIDGES.

HALEY AND OTHER LIFTING JACKS, BOILER RIVETS, &c.—SCREW BOLTS, STEEL PUNCHING BEARS.

Shearing and Punching Machines Bending Rolls, and every description of Boilermakers' Tools, &c., &c.

PERMANENT WAY.

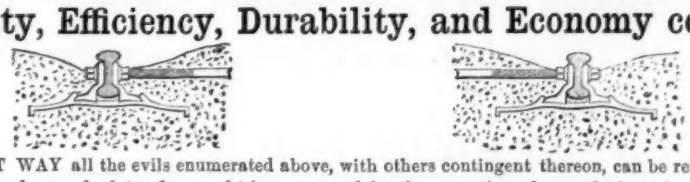
Extract from article entitled "The Railway Problem," in the *Times*, 20th October, 1869.

"The Locomotive Superintendent swears against the bad roads that wear out the tyres and axle-boxes, and breaks the springs of his engines, so that it is as much as he can do to keep the stock on the road at all."

TO RAILWAY COMPANIES AND ENGINEERS.

KNOWLES'S PATENT WROUGHT-IRON PERMANENT WAY.

Simplicity, Efficiency, Durability, and Economy combined.



By this PERMANENT WAY all the evils enumerated above, with others contingent thereon, can be remedied. Timber sleepers are replaced by a rolled and curved plate of wrought-iron, grooved for the reception of wrought-iron jaws, which hold the rail instead of the present cast-iron chairs. Rods passing from one rail to the other maintain the gauge, and nuts on the ends of the rods lock the rails in their position. Where one rail meets the other longitudinally, the ends are fished by an extra length of jaw, making the joint perfectly sound and not harsh.

The ease with which ROLLING STOCK works over this road affords greater comfort to the passengers and is less destructive to the rails, tyres, and springs.

Its great simplicity is an additional advantage, and the form of the sleeper renders the operation of packing easy, while it being a practically permanent way, a minimum amount of expenditure will be incurred for repairs or renewals.

For FOREIGN RAILWAYS it is particularly valuable. There is a reduction of over 61 tons per mile in weight as compared with cast-iron roads, causing a corresponding saving in freight and carriage, and there is no loss from breakage.

The underside of the rail, not being in contact with the chair or sleeper, is preserved for turning when the other has been worn out.

A piece of this road has been for some months past subjected to a heavy goods traffic at Stourbridge, and has fully established the foregoing facts. Detailed drawings and particulars can be obtained from—

MR. BELLINGHAM, SOLE AGENT,

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JOHN AND EDWIN WRIGHT

PATENTEES,

(ESTABLISHED 1770.)

MANUFACTURERS OF EVERY DESCRIPTION OF IMPROVED

PATENT FLAT AND ROUND WIRE ROPES

From the very best quality of charcoal iron and steel wire.

PATENT FLAT AND ROUND HEMP ROPES.

SHIPS' RIGGING, SIGNAL AND FENCING STRAND, LIGHTNING CONDUCTORS, STEAM PLOUGH ROPES (made from Webster and Horsfall's patent steel wire), HEMP, FLAX, ENGINE YARN, COTTON WASTE, TARPAULING, OIL SHEETS, BRATTICE CLOTHS, &c.

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By a special method of preparation, this leather is made solid, perfectly close in texture, and impermeable to water; it has, therefore, all the qualifications essential for pump buckets, and is the most durable material of which they can be made. It may be had of all dealers in leather, and of

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